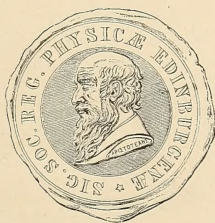


PROCEEDINGS
OF THE
ROYAL PHYSICAL SOCIETY
OF
EDINBURGH.

FOR THE PROMOTION OF ZOOLOGY AND OTHER BRANCHES
OF NATURAL HISTORY.

VOL. XIX.

1912-1915.



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NATURAL HISTORY.

SESSION 1912-1913.

No. 1.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY

SESSION CXLII.

- I.—Note on the Type Specimens of *Plumularia catharina*, Johnston, and its so-called "stemless variety." By James Ritchie, M.A., D.Sc., Royal Scottish Museum.

(Read 25th November 1912. MS. received 25th November 1912.)

IN a recent note, Dr Billard¹ has raised a question as to the specific characters of *Plumularia catharina*, Johnston. To answer this query and fix the characters of the type specimens of the species is the object of the present note.

While the general descriptions given by Johnston and succeeding authors are sufficient, the specific characters residing in the lateral nematophores have been neglected or wrongly described. Johnston himself mentions only that "between the cells there is a series of minute tubular or toothed cells." There is no mention of lateral nematophores, and his Fig. 62, in the original paper² (repeated in his subsequent monograph³) shows no sign whatever of lateral nematophores. Yet Johnston quotes with approval an observation of F. W. L. Thomas, that the internode "which bears the cell has also a cellule at its base, and two *lateral* processes about the middle: to these processes are articulated two 'trumpets,' whose height is equal to the mouth of the cell."⁴ This, I take it, means that the lateral processes bear one "trumpet" (nematophore) each. Johnston's successors, while approaching, still fall short of the truth. Landsborough first figures clearly one lateral nematophore

¹ Billard, *Arch. Zool. exp. et gén.*, 1912 (5), Tome ix., Notes et Revue, No. 3, p. lix.

² Johnston, *Mag. Nat. Hist.*, vol vi., 1833, pp. 497-499.

³ Johnston, *A History of British Zoophytes*, Edinburgh, 1838, fig. 16, p. 148; and London, 1847, 2nd ed., fig. 17, p. 98.

⁴ Johnston, *Hist. Brit. Zoophytes*, 2nd ed., Supplement, p. 465.

on each side,¹ but makes no reference to it in the text. Hincks both figures and describes "one nematophore on each side of the calyces, pedunculated," in his monograph,² and in a later paper.³ Kirchenpauer⁴ and Nutting⁵ are content to reproduce Hincks's figures and abide by his description.

Apart from these, *Plumularia catharina* has been recorded scores of times, and, except in three cases, so far as I am aware, the recorder has no observation to add, or holds to the orthodox description of the arrangement of the lateral sarcothecæ.

The three exceptions are as follows:—In 1889, Segerstedt⁶ figured specimens from the west coast of Sweden as bearing two lateral nematophores on each side, and these he distinctly describes, saying, "to Hincks's description of this species, I have to add that there occur on the sides of each calycle, inside the two pedunculated accessory calyces [sarcothecæ] mentioned in descriptions, also a pair of smaller, sessile structures of a similar nature." In 1909 Dr Jäderholm, in his valuable monograph on "Northern and Arctic Vertebrates in the Swedish State Museum,"⁷ gives a beautiful figure of *Plumularia catharina* in which two lateral sarcothecæ are shown on each side of the hydrotheca, but no reference is made to this feature in the text. Lastly, Dr Billard, in the note already mentioned, has drawn attention to the discrepancy in descriptions, in the hope that the question may be settled by direct examination of the type specimen.

Johnston first described the species in 1833, and although in his account he does not single out a specimen as typical, and indeed does not even mention the locality from which the figured example was obtained, yet it is clear from his remark—"Specimens are not uncommon in Berwick Bay; and I have seen the same from the Firth of Forth"—that he would have regarded the former locality as one characterised by the presence of typical examples of the species. In 1847, the year in which the second

¹ Landsborough, *A History of British Zoophytes or Corallines*, London, 1852, pl. ix. fig. 27.

² Hincks, *A History of British Hydroid Zoophytes*, London, 1868, p. 299, pl. 66 figs. 2, a and b.

³ Hincks, *Ann. Mag. Nat. Hist.*, series 4, vol. x., pl. xxi. figs. 4 and 5.

⁴ Kirchenpauer, *Abh. a.d. Gebiete d. Naturwiss.*, Hamburg, 1876, Taf. i., fig. 12.

⁵ Nutting, *American Hydroids*—pt. i., "Plumulariæ"—Washington, 1900, pl. iii. figs. 1 and 2.

⁶ Segerstedt, *Bihang. Kungl. Vet.-Ak. Handl.*, Stockholm, Bd. xiv., 1889, Afd. iv., No. 4, p. 21, fig. 2.

⁷ Jäderholm, *Kungl. Vet.-Ak. Handl.*, Stockholm, Bd. 45, No. 1, 1909, pp. 30, 37, 107, pl. xii. fig. 7.

edition of his *British Zoophytes* appeared, "Dr G. Johnston, of Berwick, most kindly presented to the [British] Museum the whole of his Collection, which he used in the preparation of his classical work on the subject." According to Gray's *List of the Radiated British Animals in the Museum*,¹ published in the succeeding year, Johnston's collection contained five specimens, type and co-types, of "*Aglaophenia*" *catharina*, all from Berwick Bay.

These—dry specimens mounted neatly on small plates of mica, or loose



FIG. 1.

Portion of hydroclade from one of Johnston's specimens of *Plumularia catharina*. $\times 50$.



FIG. 2.

Lateral aspect of hydrotheca of *Plumularia catharina*. $\times 88$.

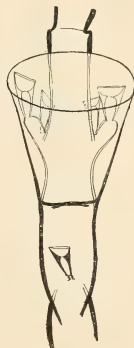


FIG. 3.

Anterior aspect of hydrotheca of *Plumularia catharina*. $\times 88$.

in paper packets—I have examined, by favour of the authorities at the British Museum (Natural History), and the examination confirms the observations of Segerstedt and his followers (see Fig. 1). *Plumularia catharina* is furnished not only with a single pedunculated lateral sarcotheca on each side of the hydrotheca, but, in addition, bears a smaller, sessile supplementary individual on each side, set almost in the angle between the internode and the "peduncle" of the lateral sarcotheca. The main lateral sarcotheca falls short of the level of the rim of the hydrotheca; the supplementary individual is scarcely longer than the process upon which the main individual is set. But the proportions can be better studied in a fresh specimen (see Figs. 2 and 3).

¹ Gray, *List of the Specimens of British Animals in the Collection of the British Museum*, Part i., "Centroniae or Radiated Animals," London, 1848, p. 81.

It has been generally admitted that this character of a pair of lateral sarcothecæ on each side is of specific significance. Nutting (1900, p. 81) even regards it as of generic importance. *Plumularia catharina* has this character; but it is possible that the branched species so consistently described by authors as possessing only a single lateral sarcotheca on each side also exists, and is a species distinct from that of Johnston.

In an endeavour to settle this question, I have examined specimens with the facies of *Plumularia catharina* from the following localities, widely distributed off Scottish coasts:—Tiumpan Head, N.W. \times W. $\frac{1}{2}$ W. 8 miles, 100 metres; Brora, W.N.W. $\frac{1}{2}$ mile, 16 fathoms; Cromarty Harbour, 18 metres; Burghead, S. \times E. $5\frac{1}{2}$ miles; off Burghead and Lossiemouth 20-30 fathoms; Lunna Holm, Shetland, N.W. 5 miles; and "Goldseeker" stations, Nos. 7, 16, 41 and 56.¹ Every specimen showed the characters of Johnston's type. The probability, therefore, is that a species with solitary lateral sarcothecæ is exceedingly rare in British waters, if indeed such a species exists at all.

Johnston and Hincks considered that there existed a "stemless variety" of *Plumularia catharina*, supposed by the latter to be *Plumularia secundaria* (Gmelin), and some later investigators have upheld this relationship of the two forms. The so-called "stemless variety," however, is a distinct species. I have examined and recorded examples of it from the Mergui Archipelago, Burma; Interview Island, Andamans; Gulf of Manaar, Ceylon; and the Dogger Bank, North Sea. And in each case the specific characters agree with those of *Antenella* (*Plumularia*) *secundaria*, given by authors: the hydrotheca is flanked by a single supracalycine sarcotheca on each side, while above it, in the angle behind the hydrotheca, lies an insignificant unpaired median individual.

The facts, therefore, that *Plumularia catharina* possesses a pair of lateral sarcothecæ on each side, while *Antenella secundaria* has only one a side, and a single median individual above the hydrotheca, are sufficient to separate these species—apart altogether from their very different habit.

On the other hand, an unsuspected resemblance is revealed between the minute characters of *Plumularia catharina* and those of *Antenella quadriaurita*, Ritchie, obtained by the Scottish Antarctic Expedition from Gough Island, in the South Atlantic; for the latter, possessing the habit

¹ For permission to use these records of material collected by the Scottish branch of the North Sea International Investigation, I am indebted to Prof. D'Arcy W. Thompson, C.B. Figs. 2 and 3 are from a Lunna Holm specimen.

of *Antenella*, is, like a few other species of this genus, also furnished with two pairs of supracalcine sarcothecæ.

SUMMARY.

The type specimens of *Plumularia catharina* have, in addition to the pair of supracalcine sarcothecæ usually described and figured, a smaller supernumerary pair lying at the base of the former. The so called "stemless variety" is a distinct species, *Antenella secundaria* (Cavol.).

(Issued separately, 23rd January 1913.)

II.—On the Invalidity of the Hydroid Genus, *Diplopteron*, Allman.

By James Ritchie, M.A., D.Sc., Royal Scottish Museum.

(Read 25th November 1912. MS. received 25th November 1912.)

THE presence of more than one pair of lateral sarcothecæ has been observed in several Plumularian species. On this account, together with the possession of doubly pinnate ramification, Allman created the genus *Diplopteron*.¹ Bale suggested, "if this genus be retained . . . that it be modified so as to comprise all species with more than one pair of lateral nematophores";² and Nutting accepts this character as distinctive of the trophosome, adding, as characterising the gonosome, "gonangia protected by accessory ramuli borne on the hydrocladia, and bearing a few scattered hydrothecæ."³ He specifically excludes *Plumularia sulcata*, Lamk. (= *aglaophenoides*, Bale) from this genus, and would place it in a genus by itself on account of its fixed mesial sarcotheca.

But what is the true status of the "two or more pairs" of lateral sarcothecæ amongst the Plumularidæ? They occur after two main types. The primary pair in each type is similar: elongate sarcothecæ lying one along each side of the hydrotheca, and supported upon a process from the hydroclade adnate to the hydrotheca wall. But the additional pair or pairs may be indefinite or definite in position. In the former case, the additional sarcothecæ rise distinctly from the internode wall some distance above the primary sarcothecæ, their position as a pair is not fixed in any species, they do not lie necessarily in the same relative position to each other, *e.g.* the individuals of a pair frequently do not originate in the same horizontal plane at right angles to the long axis of the internode, and in some species, at least, the pair may be replaced by a single median individual. In such a group fall *Plumularia sulcata*, Lamarck (= *aglaophenoides*, Bale), *Polyplumularia flabellata*, G. O. Sars, *Diplopteron grande*, Nutting, *Diplopteron quadricorne*, Nutting, and *Diplopteron longipinna*, Nutting.

In the second type, the additional pair of sarcothecæ rises just at the base of the processes supporting the primary lateral sarcothecæ. Since these processes are fixed, the positions of the sarcothecæ as individuals and as a pair are thus definite and fixed, and in the same horizontal plane. Nor has such a pair been observed to have been replaced by a single median individual. The additional sarcothecæ here are distinctly lateral, and may

¹ Allman, *Trans. Zool. Soc.*, London, 1874, vol. viii. p. 479.

² Bale, *Cat. Australian Hydroid Zoophytes*, Sydney, 1884, p. 124.

³ Nutting, *American Hydroids*, pt. i., Washington, 1900, p. 81.

be considered as appendages supplementary to the primary lateral sarcothecæ. Such supplementary lateral sarcothecæ are exhibited by the species re-described in the preceding paper,—*Plumularia catharina*, Johns.,—by *Antennopsis scotiae*, Ritchie,¹ *Diplopteron insigne*, Allman, *Antenella quadriaurita*, Ritchie, and *A. sibogæ*, *A. varians*, and *A. balei*, all of Billard; although the three last possess in addition paired sarcothecæ of the indefinite type.



Anterior aspect of *Polyplumularia flabellata*,² showing indefinite type of arrangement of additional pair of lateral sarcothecæ. × 88. (Compare *Plumularia catharina*, with definite arrangement, Fig. 3 of preceding paper, p. 3.)

The presence, therefore, of more than one pair of lateral sarcothecæ occurs, according to present classification, in, at least, these genera of Plumularidæ—*Plumularia*, *Antenella*, *Diplopteron*, *Polyplumularia*, and *Antennopsis*. These genera are distinguished by characters of branching, of arrangement of hydrocladia, and by the presence or absence of special offshoots of the hydrocladia for the protection of the gonangia. However one may regard the exclusive use of characters of branching in distinguishing genera, it is impossible that all the distinguishing features involved in the separation of these genera are to be nullified in view of the presence of additional pairs of sarcothecæ, which, as has been indicated, belong to two distinct types.

The genus *Diplopteron*, which was formed to contain such diverse forms as have been enumerated, seems to me therefore to be untenable.

¹ See Ritchie, *Trans. Roy. Soc.*, Edinburgh, 1909, vol. xlvii., pt. i., p. 90, fig. 8.

² Specimen from Loch Lorne, Scotland.

III.—Notes on *Chiastopsylla*, Rothsch., a genus of Siphonaptera, with description of a New Species (*Ch. godfreyi*). By James Waterston, B.D., B.Sc.

(Received 12th November 1912. Read 25th November 1912.)

DURING the past two years I have received from the Rev. Robert Godfrey, M.A., Pirie, King William's Town, South Africa, several specimens of *Chiastopsylla* (3), which prove, with one exception, to be *C. rossi*, Waterst. (2). This example, a ♂, I propose to name in honour of my friend, whose brilliant field work amongst the Invertebrata of his district has already produced many new and interesting species.

Chiastopsylla godfreyi, sp. nov.

HEAD.—The head is evenly rounded with only a slight frontal notch. The first three joints of the maxillary palpus are sub-equal, and the last is as long as the two preceding, together. The proportions are 11 : 9 : 10 : 19.

THORAX.—

The pronotum has a row of about 10 thin bristles before the comb.

The mesonotum shows a basal row (about 12) of fine hairs below the comb, a scanty median row (5 or 6) of bristles, and a post-median row of 10.

The metanotum bears a median row (about 3), a post-median row (10), and 4 teeth.

The epimeron bears 5 bristles (2, 3).

ABDOMEN.—The bristles of the abdomen are as follows :—

	I.	II.	III.	IV.	V.	VI.	VII.
<i>Tergites</i> , Ante-Median Row	6	2	2	4	3	3	3
„ Post-Median Row	9	14	14	13	14	11	11
„ Teeth	2	2	2	2	...	...	...
<i>Sternites</i> . . . .	...	2	4	4	4	4	4

Tergites 2-7 have on each side a bristle (the 5th has 2) below the stigma.

LEGS.—The hind coxa bears 5 short spines on its internal surface, one being set apart from the others near the edge. The hind femur has

6-7 external lateral bristles in a row; there is one extra spine at the edge between the 4th and 5th pairs. The proportions of the tarsal joints are—

1st tarsus	.	.	12, 13, 11, 10, 22.
2nd „	.	.	22, 22, 15, 11, 25.
3rd „	.	.	50, 35, 20, 14, 26.

In the 3rd tarsus, therefore, *C. godfreyi* is practically the same as *C. rossi*.

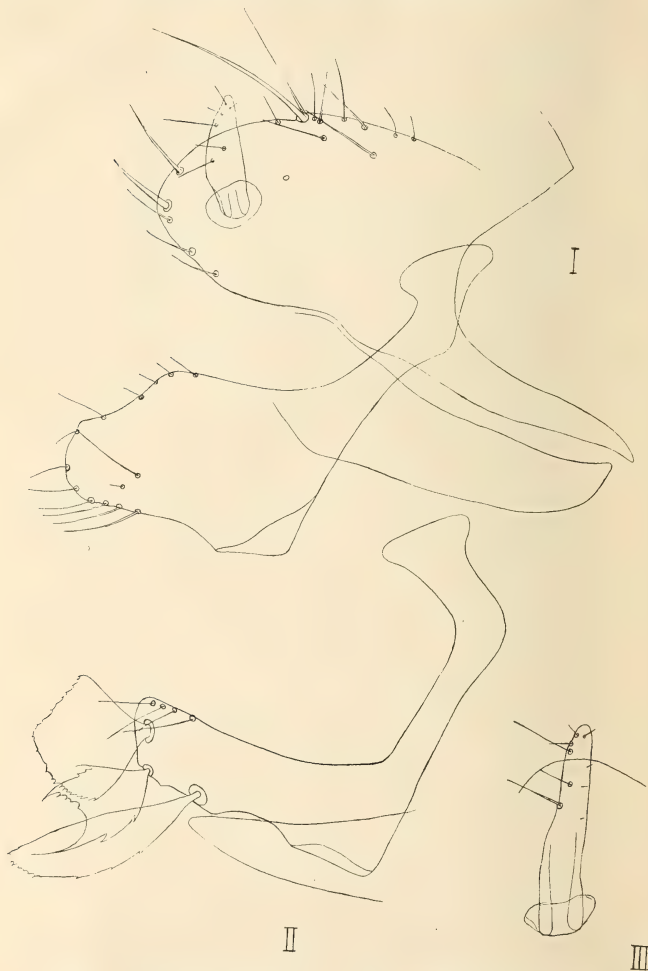
The apical bristles of the 1st and 2nd hind tarsal joints are very long, equal in length, or nearly so, to the three succeeding joints.

MODIFIED SEGMENTS, ♂.—The 8th tergite is small, scale-like and naked, but the corresponding sternite is normally developed and bears 3 bristles on each side. The clasper, besides other hairs or bristles, bears 3 strong bristles at the edge, viz. 1 placed dorsally behind the middle, while 2 are disposed distally—the more ventral being short and stout (see Fig. 1). The “finger” is broader and shorter than in *C. numæ* and *C. rossi*, but the hairs are similar, viz. 3 short ones at the apex, and two longer, one below the apex and another about the middle. The 9th sternite is broad ventrally, and the edge is fringed with hairs. The internal plate of the penis is shorter than the manubrium, which, in this species, is long, slender, and downwardly curved.

LENGTH of ♂, 1.6 mm.

TYPE.—A ♂, in the author's collection, taken by Miss Fanny Ross from *Arvicanthus pumilio*, Pirie Mts., nr. King William's Town, So. Africa., July 1911.

Remarks on *Chiastopsylla*.—I take the opportunity of referring here to the male characters of *Chiastopsylla*. In *C. numæ* and *C. rossi* the head is produced before the maxillary palpus, and this prolongation meets the descending frons in a remarkably acute angle: the 8th sternite is reduced, and the 9th sternite bears distally three leaf-like appendages (modified hairs). In *C. godfreyi* the head rises in a gentle curve directly from the base of the palpus, and the forehead is furnished with the merest notch; the 8th sternite is entire, and the 9th unadorned. In all three species the 8th tergite is presumably small, and without bristles. Another common feature is the division ventrally of the 9th sternite. In *C. rossi* and *C. godfreyi* this is apparent, and the junction of the halves is sensibly thickened. The fixed portion of the clasper, oblong in shape with rounded angles, bears on the dorsal edge, besides other hairs or bristles, one stout bristle at or a little

FIG. 1. Ninth segment of *C. godfreyi*.FIG. 2. Ninth sternite of *C. rossi*.FIG. 3. Finger of clasper of *C. rossi*.

beyond the middle, with two external finer bristles beneath, set near the edge and parallel with it. There is also at least one stout bristle on the posterior edge.

C. rossi, ♂, closely resembles *C. numæ* in the 9th tergite. In both species the "finger" is long and narrow, though the hairs appear to be longer in *C. rossi*. The two species, however, can be easily separated. In *C. numæ* the 8th sternite is "finger-like," being developed only ventrally. In *C. rossi* the corresponding portion of the sclerite is cuneate and bears a few hairs. Above the wedge is a crescentic sinus, and above this again the sternite is produced into a short, broad lobe. The appendages of the 9th sternite differ in the two species. In *C. numæ* they are roughly diamond-shaped, terminating in a long point with frayed edges, in the case of the upper two. In *C. rossi* only the lowest is elongate; the uppermost is short and broad, while the middle one is deeply indented. In *C. numæ* the scales overlap from above downwards; in *C. rossi*, in the reverse order. As one would expect, the male of *C. rossi* is somewhat more heavily armed with teeth on the tergites than is the female. The metanotum bears 4-6 teeth, and the first four tergites 2-4, 2-4, 2, 2, respectively. In general chætotaxy the male resembles the female. Length, 1.6 to nearly 2 mm.

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2. WATERSTON, J. A New *Ceratophyllus* from South Africa, *E.M.M.*, ii., pp. 271-273, No. 547, pl. v. figs. 3, 4 (1909).
3. ROTHSCHILD, N. C. *Chiastopsylla*, a new genus of Siphonaptera, *Ent.*, p. 105, No. 563 (1910).

(Issued separately, 15th March 1913.)

IV. — A New Species of *Ischnopsyllus* (*I. ashworthii*) parasitic upon the Cape Horse-Shoe Bat (*Rhinolophus augur*). By James Waterston, B.D., B.Sc.

(Received 12th November 1912. Read 25th November 1912.)

AMONGST some Siphonaptera forwarded during the past six months from Pirie, King William's Town, South Africa, by the Rev. Robert Godfrey, M.A., there was included an interesting bat flea which appeared to represent a new species. In this opinion the Hon. N. Charles Rothschild, M.A., to whose generous help the writer has so often been indebted, entirely concurs. It is with great pleasure that the writer dedicates this new form to Dr J. H. Ashworth.

Ischnopsyllus ashworthii, spec. nov.

HEAD.—The frontal portion bears, parallel to the antero-dorsal edge (as seen in side-view), a row of hairs, which, exceedingly minute at first, increase both in length and strength posteriorly. The last hair of this row stands at the edge of the antennal groove just above the base of the first joint of the antenna. Below, on the side of the head, there are three stout bristles arranged in a triangle. Inferior to these again and somewhat in front are one or two short hairs. A stout spine, rising from the edge of the antennal groove, opposite the insertion of the third joint of the antenna, reaches as far as the base of the first coxa. The genal process is long; the ventral portion of its hind edge is straight, but the dorsal portion is slightly produced. Behind the antenna the head is densely clothed with bristles, arranged in about five irregular rows. The hindmost row is composed of stouter elements, and the first bristle of each row is stronger than the others. There is, therefore, above the short hairs fringing the antennal groove, a well-marked cross row of bristles. At the lower corner of the antennal groove stands a stout, sharp spine.

THORAX.—

(a) *Prothorax*.—*Pronotum*—has 3 irregular rows of bristles, about 8 in each row, and a long bristle or spine near ventral angle. The comb consists of 19 teeth.

Prosternum, bare.

(b) *Mesothorax*.—*Mesonotum*—long and bristly, having 5 irregular rows of bristles (6-7 units in each). Near the posterior edge are 9 peculiar spine-like projections (arranged 2 on each side ventrally and 5 medianly), which, as they do not rise directly from the edge, can hardly be homologous with the teeth of a comb but are probably to be regarded as modified hairs. They are broad at the base and taper abruptly to a fine point. Similar structures have been described by Rothschild in *I. aegyptius*.¹

Mesosternum—(a) *sternite*, bare; (b) *episternite*, with 3 bristles; (c) *epimeron*, with 4 bristles, and one bristle on the chitinous rib separating the episternite and epimeron.

Spiracle exposed.

(c) *Metathorax*.—*Metanotum*—has 5 irregular rows of bristles. The hindmost row (consisting of about 8 units) stands upon the thickened rib of chitin. The comb consists of 15 teeth.

Metasternum—(a) *sternite*, bears 1 stout bristle at upper posterior edge; (b) *episternite*, narrow, with 1 bristle; (c) *epimeron*, with 4 bristles (1, 2, 1).

ABDOMEN.—The following is the arrangement of bristles, spines, etc. There are combs on segments 1 and 2.

	I.	II.	III.	IV.	V.	VI.	VII.
<i>Tergites</i> , Bristles . . .	8	11	11	11	11	11	10
„ Teeth in Comb . . .	15	11	...	...	...	...	...
<i>Sternites</i> , Bristles . . .	...	2	2	4	4	4	10

The first tergite, which closely resembles in chaetotaxy the tergites of the thorax, bears about 4 rows of bristles. The last row (the only one enumerated in the above table), placed immediately before the comb, is more regular, and consists of stouter bristles than are found in the other rows. It does not appear to be strictly comparable with the rows of similar bristles on tergites 2-7. The latter are somewhat post-median, their line going through the stigma, whereas on the first tergite the chief row is placed far behind the stigma, which is covered by the metathoracic epimeron.

¹ *Ent. Mo. Mag.*, Second Series, vol. xiv. (1903), pp. 83, 84, pl. i. fig. 1.

Legs.—*Fore coxa*, with a row of short bristles at edge, about 30 bristles on the external surface, one long bristle at the posterior edge below $\frac{1}{2}$, and one shorter near the apex. *Mid and Hind coxae*, externally bare, save for one or two bristles in line with the edge near the apex. The usual fringing row of short bristles is present.

Femur.—Besides the 2 sub-apical ventral bristles there are only one or two others which are placed laterally near the apex.

Tibiae.—The rows of external bristles are respectively: (a) *Fore tibia*, 8; (b) *Mid tibia*, 11; (c) *Hind tibia*, 14 (this row is double from 10th-14th bristle).

MODIFIED SEGMENTS, ♀ (see Fig.).—The 7th sternite, which bears 5 bristles on each side, has an undulated outline. The ventral angle is sharp, and, when the sternite is flattened out, there is a small but very distinct median point. The 7th tergite bears one antepygidial bristle accompanied by two small ones. The 8th sternite, which is very inconspicuous, has also an undulated outline. The corresponding tergite bears externally about 16 bristles, disposed as shown in the figure. About the middle of the posterior edge (but rising from the inner aspect) is a group of 3-4 short bristles. A portion of the 9th sternite projects, in the type, beyond the outline of the 8th tergite, and this has been shown in the figure. At the posterior ventral angle of the 9th tergite there is one long bristle, and indication of another (short) before the *stylet*, which is about four times as long as broad. It bears one or two bristles terminally. The 10th segment is bristly—particularly the sternite, which is deep.

LENGTH.—♀, 2.5 mm.

TYPE.—One ♀, in the author's collection, taken from Cape Horse-Shoe Bat (*Rhinolophus augur*, K. And.), 17: xi.: 11. Collected by Miss Fanny Ross, Pirie, King William's Town, South Africa.

V. — **Scotia Collections — Siphonophora of the Scottish National Antarctic Expedition.** By J. H. Koeppern, Zoological Department, University of Edinburgh.

(Received 13th December 1912. Read 16th December 1912.)

THE Siphonophora collected by the Scottish National Antarctic Expedition (1902-1904) were kindly entrusted to me for examination by Dr W. S. Bruce, to whom my thanks are also due for the loan of literature and charts, and for the permission to reproduce three photographs previously published in the Zoological Log of the expedition. I am grateful to Dr J. H. Ashworth for various suggestions during the course of my work.

The notorious difficulty of satisfactorily preserving such fragile forms of animal life has made the specific determination of a few of the specimens somewhat difficult. Some of the Physaliæ and Velellæ, however, are excellently preserved in formalin.

The structures described by Professor J. Arthur Thomson¹ as separated gonostyles of "Scotia" Siphonophora from the South Orkneys, probably belong to the species *Myriothecha austrogeorgia*,² whereas the detached tentacles referred to the Siphonophora by Dr J. Rennie³ must be considered as parts of *Desmonema*.⁴

Family **PORPITIDÆ**, Brandt, 1835.

Genus **Porpita**, Lamarck, 1816.

Porpita umbella, O. F. Müller, 1776.

Eleven specimens referable to this species were collected from shore pools at Scotia Bay, South Orkneys, 2nd February 1904, the temperature being a little below freezing-point. Their diameters in the preserved state range from 7 to 12 mm. This is the most southern station from which the species has been recorded.

The macerated pneumatophore of a Porpitid, with a diameter of 3 mm., was caught in the tow-net at the surface, at Station 30, 11° 15' N., 25° 20' W., temp. 79° F. Small isolated tentacles closely resembling those of the Scotia Bay Porpita were preserved along with some Velellæ from Station 53, St Paul Rocks.

¹ *Proc. Roy. Phys. Soc. Edinburgh*, vol. xvi. (1904), pp. 19-22, 1 pl.

² J. Ritchie, "Supplementary Report on the Hydroids of the Scottish National Antarctic Expedition," *Trans. Roy. Soc. Ed.* (1909), vol. xlvii., pt. i., No. 4, p. 69.

³ *Proc. Roy. Phys. Soc. Ed.*, vol. xvi. (1904), pp. 25-27, 1 pl.

⁴ E. T. Browne, "Medusæ," *National Antarctic Expedition* (1910), v., p. 51.

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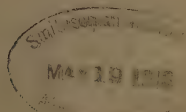
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Family **VELELLIDÆ**, Brandt, 1835.Genus **Velella**, Lamarck, 1816.**Velella velella**, Linnæus, 1758.*Velella spirans* (Forskål, 1775).

In accordance with the strict application of the rules of priority, *V. velella* seems to be the correct name of this species. Specimens were obtained at Station 51 (1° 27' N., 27° 56' W., temp. 80·1°, Dec. 8th, 1902), and at Station 53 (0° 55' N., 29° 22' W., temp. 79·8°, Dec. 10th, 1902). One well-preserved specimen is unlabelled, but has possibly been caught at Station 52 (1° 22' N., 28° 10' W., temp. 80°, Dec. 9th, 1902). According to the Zoological Log¹ Velellæ were also seen during the voyage at—

Stat. 61.	3° 38' S.	33° 20' W.	Temp. 79°	Dec. 13th, 1902.
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Stat. 95.	32° 15' S.	47° 30' W.	Temp. 74·9°	Dec. 27th, 1902.
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Stat. 360.	40° 59' S.	55° 04' W.	Temp. 61·6°	Jan. 25th, 1904.
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Stat. 362.	43° 33' S.	55° 07' W.	Temp. 60°	Jan. 27th, 1904.
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If the specimens are regarded from their longer side, the sail or crest runs from N.E. to S.W., as Agassiz found to be invariably the case in hundreds of Velellæ which he observed. Out of seventy-seven specimens examined by Chun,² seventy-one were of the type described, but in six the crest ran from S.E. to N.W. Lens and van Riemsdijk³ state that in all five specimens of *V. pacifica*, collected by the Siboga expedition, the direction of the crests was S.E. to N.W.

The three Velellæ from the "Scotia," Station 51, were partly macerated; they measure respectively 42, 66 and 68 mm. in length, 16, 26 and 36 mm. in breadth, and the crest is 16, 29 and 23 mm. in height. Nine specimens, all of which are macerated, so as to leave only the chitinous⁴ supporting substance, were taken at Station 53. The average dimensions of the "Scotia" Velellæ are, approximately, length 54 mm., breadth 20 mm., and height of crest 20 mm. On four of the specimens from St Paul Rocks, numerous white spiral coils, measuring from 2 to 9 mm. in diameter and being of a beady appearance, were observed. A microscopic examination showed them to be segmented eggs, probably those of a gastropod. As regards the distribution of the genus *Velella* in the Atlantic, the Flannan

¹ Scott, *Nat. Antarc. Exped.*, "Sci. Results Voyage 'Scotia,'" vol. iv., pt. i. (1908).

² C. Chun, *Die Siphonophoren der Plankton-Expedition*, Kiel and Leipzig (1897).

³ A. D. Lens and T. van Riemsdijk, *The Siphonophora of the Siboga Expedition*, Leiden (1908).

⁴ M. Henze, "Notiz über die chemische Zusammensetzung der Gerüstsubstanz von *Velella spirans*," *Hoppe Seyler's Zs. physiol. Chemie.*, L.V. (1908).

Isles (W. E. Clarke) and lat. $43^{\circ} 33' S.$ (Bruce) seem to be the present known northern and southern limits.

Family **PHYSALIDÆ**, Brandt, 1835.

Genus *Physalia*, Lamarck, 1816.

Physalia arethusa, Browne, 1756.

Chun¹ distinguishes only two species of *Physalia*, the Atlantic-Mediterranean *P. arethusa* and the Indo-Pacific *P. utriculus*, since the

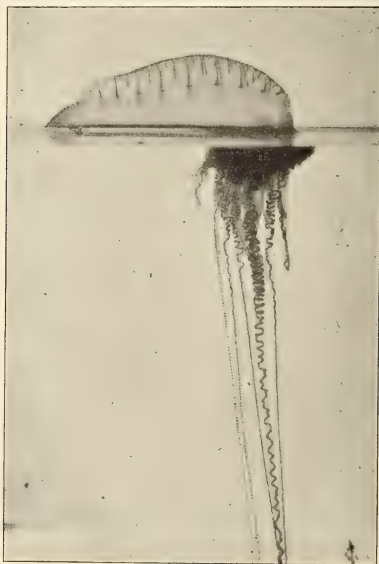


FIG. 1.

numerous species previously described have either been discovered to be young specimens or slight local variations. Specimens were collected at the following stations:—

Stat.	30.	$11^{\circ} 15' N.$	$25^{\circ} 20' W.$	Temp. 79°	Dec. 4th, 1902.
Stat.	81.	$18^{\circ} 24' S.$	$37^{\circ} 58' W.$	Temp. 79.9°	Dec. 20th, 1902.
Stat.	478.	Table Bay.	May 1904.		
Stat.	527.	$11^{\circ} 32' N.$	$20^{\circ} 30' W.$	Temp. 78.1°	June 19th, 1904.

¹ C. Chun, *Die Siphonophoren der Plankton-Expedition*, Kiel and Leipzig (1897).

The occurrence of Physaliæ has been recorded in the Zoological Log at Stations 42, 53, 57, 60, 72, 78, 82, 83, 95, 97, 508, 509, 525, 529, 530 and 531.

The five young Physaliæ taken in the tow-net at Station 30 have well developed pneumatophores 3, 3·5, 4, 6 and 12 mm. in length respectively, that of the largest specimen exhibiting a comparatively large polythalamic

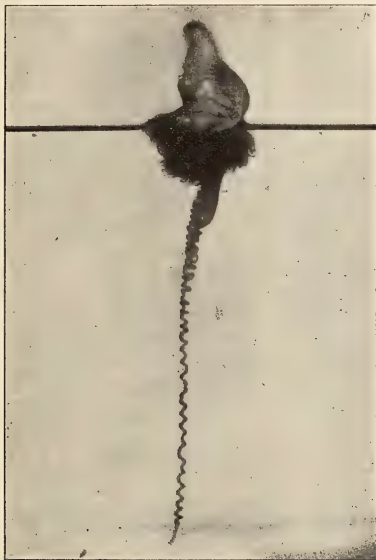


FIG. 2.

crest. Although not well preserved, several small siphons and a larger central one could be distinguished. The two specimens from Station 81 are very well preserved. The length of their pneumatophores measures roughly 9 and 10·5 cm., the breadth 4 and 4 cm., and the thickness, including crest, 5 and 4·5 cm. respectively. The crest and cormidia are well developed. Each specimen has about ten tentacles, the longest of which is in one case 30 cm., and in the other 24 cm. The example recorded from Table Bay (Station 478) is not in a very good state of preservation, the remnants

only of a few tentacles being present. The pneumatophore is 8 cm. long; the gastrozooids and gonozooids, though well developed, are much shrunk. The three well-preserved specimens from Station 527 differ from those of Station 81, in having one tentacle more highly developed than the others.

A faint tinge of pink is still noticeable in parts of their pneumatophores

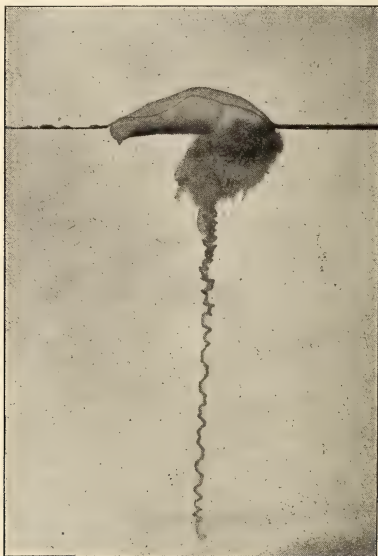


FIG. 3.

and in some of the zooids. A coloured sketch of a *Physalia*, which was caught at Station 78, was made at the time and shows the edge of the crest as being of a delicate pink, whereas the aboral pole of the pneumatophore, the zooids and the tentacles, are depicted as being of a vivid dark blue. The three photographs show the turning over on its side of a *Physalia*, which thereby presents a smaller surface to the wind.

Family **DIPHYIDÆ**, Eschscholtz, 1829.

Apart from a few not identifiable pieces of jelly, altogether eight nectophores of Diphyids, ranging from 24 to 40 mm. in length, were taken by the trawl (2300 f. to surface), at—

Stat.	53.	St Paul Rocks.	Temp. 79°	Dec. 10th, 1902.
Stat.	286.	68° 11' S. 34° 17' W.	Temp. 29°	March 5th, 1903.
Stat.	396.	67° 53' S. 27° 20' W.	Temp. 29·2°	Feb. 29th, 1904.
Stat.	416.	71° 22' S. 18° 15' W.	Temp. 29·6°	March 17th, 1904.
Stat.	450.	48° 00' S. 9° 50' W.	Temp. 40°	April 12th, 1904.

Three Eudoxiæ must be mentioned here, two from Station 396, and one from Station 450. The unsatisfactory state of their preservation makes all but the reference to the above family possible as regards classification. Their habitat, however, is of interest, as extending the range from which they have previously been recorded. The discovery of Diphyids as far south as 71° 22' corresponds to their occurrence in Arctic seas.

(*Issued separately, 10th April 1913.*)

VI—Ecology, the best method of studying the Distribution of Species in Great Britain. By C. B. Crampton, M.B., C.M., of H.M. Geological Survey.

(Received 17th February 1913. Read 27th January 1913.)

1. The Replacement of the Natural by the Artificial.
2. The Difficulties of the Problem of Distribution, and the Artificiality of the Present Methods of Recording Distribution, are chiefly Results of this Replacement.
3. The Probable Effect of Man's Interference on the Distribution of Species.
4. Ecology the Proper Method for Recording Distribution.

1. THE REPLACEMENT OF THE NATURAL BY THE ARTIFICIAL.

In parts of this country, one may now travel miles and fail to detect a single spot left as virgin ground. In the remoter districts extensive tracts of moorland still show, it is true, a close approach to these conditions, and smaller patches of moor, heath, fen, marsh, natural wood and grassland are widely scattered through the kingdom.

Surroundings where the naturalist feels confidence in a truly aboriginal interrelation of the various forms of life, such as results from centuries of unrestricted competition and selection, are, however, becoming scarcer every year. The replacement of the natural by the artificial proceeds apace, and the delicate interrelations between the fauna and flora and their habitats have been rudely disturbed, and, in many places, long superseded by entirely, new and, at best, coarsely adjusted conditions. Not only the original life associations, but the soil and drainage also, have undergone a complete revolution to meet the economic requirements of man.

As the outcome of these changes, certain time-honoured associations of plants and animals with their habitats have been destroyed, or much curtailed and restricted to small areas well known to, and beloved by, naturalists; while other new, and frequently loosely associated, groups have sprung into existence, either at the instigation of man and with his direct help and consent, or without it, and, not seldom, to his annoyance and detriment.

The ways and results of this disturbance have, indeed, been manifold. In the first place, man destroyed the larger part of the woodlands formerly clothing the lower ground and sheltered slopes of our mountain districts, and constituting the stronghold of the wolf, wild boar and other animals against which he exercised constant warfare.

The virgin woodlands had certain defined associations of plant and animal life, forming through their balanced interdependence a closed barrier to invasion by exotic species. Much of the ground they occupied is now periodically turned over by the plough. The original soil, rich in humus and with a specialised micro-flora and fauna, the result of generations of forest growth and decay, has been roughly replaced by an artificial product constantly subjected to disturbance and alteration to meet economic requirements. The relatively stable, physical and chemical constitution of the virgin soil, with its finely zoned and layered structures, upon which the needs of the varied species of the virgin associations depended, has been destroyed.

The virgin forest and virgin soil, within certain limits, were self-supporting and self-protective, but the usurping agricultural ground has to be frequently doctored to renew the materials carried away in the crop, or wasted in the drainage waters. Neglect, or a bad season, results in an invasion of weeds, varying in kind with the rotation or fallow, mostly foreign to the original vegetation, but now, in ill-assorted groups, occupying all artificially formed new ground remote from virgin plant associations.

Having destroyed the forests, man proceeded to form artificial woodlands by planting. In so doing, he not only dislocated various tree-species from the habitats to which they were originally closely confined through natural selection and adaptation, but further, planted them in parts of the country where they were formerly non-existent, and even introduced species (*e.g.* larch and sycamore) from abroad. Bushes taken from specialised surroundings soon formed a network of hedgerows over miles of country, and certain species of native trees (*e.g.* ash and beech) were selected and spread widely beyond their original confines, on account of their usefulness for timber or other purposes, or from the ease with which they could be reared in civilised surroundings.

In plantations we often find, side by side, different trees which, in nature grow as pure, or almost pure, forest associations. The trees may, further, be planted with little consideration as to their natural habitat, in a way that often spoils the harmony of the scenery. A natural vegetation, be it vast stretches of moor or forest, or scattered, smaller patches of various formations, always blends harmoniously with the physiography, and, indeed, forms a natural clothing in which every earth feature has the appropriate garment for the season and the climate.

Orchards of selected varieties of British and foreign fruit trees present us with an entirely artificial type of bushland or scrub, consisting of trees which are usually found in nature widely scattered, singly, or as small groups in special habitats, where competition with forest trees is limited. As with other

crop-plants grown closely together, we find that orchards have certain insect and other pests closely associated with them without the natural restrictions found in virgin associations, and these have to be specially guarded against wherever orchards are planted.

On the other hand, the spread of a southern fauna into formerly isolated moorland districts has sometimes led to disaster in the extensive pure associations of our native birch woods. Thus planted associations are liable to destruction from the unevolved and unbalanced condition of their vegetation and insect or other fauna, but naturally evolved associations only suffer when their natural balance is disturbed.

The grasslands, marshes and fens of the low-lying alluvial stretches have had much of their original plant associations eradicated by drainage or by the plough. Even the coastal sand dunes, so long almost disregarded by the economist, are now being remorselessly civilised by the golfer and the mowing-machine, so that many close adaptations and associations of plant and animal life to their surroundings will be rapidly replaced by patches of weeds and artificially formed grassland.

Wide stretches of heath and moor, owing to greater difficulties in their profitable reclamation, have stubbornly repelled the attempts of the agriculturist to annex their territory, and certain grassy uplands of the chalk downs have passed into his keeping without suffering much change. The wilder moorland still forms a sanctuary for the grouse and mountain hare with their attendant foxes, peregrines and eagles, but much of it has been turned into deer-forest where unnatural numbers of red deer are kept in a semi-domesticated condition, freed from the enemies that formerly exercised a more selective control upon their destiny.

By ruthless forest exploitation, by burning the heather, artificial drainage, overstocking with deer, by the introduction of sheep and rabbits, and by the destruction of the natural predatory birds and mammals, much alteration has been effected even in remote parts of our moorland, and many associations have succumbed and others are driven to the verge of extinction.

2. THE DIFFICULTIES OF THE PROBLEM OF DISTRIBUTION, AND THE ARTIFICIALITY OF THE PRESENT METHODS OF RECORDING DISTRIBUTION, ARE CHIEFLY RESULTS OF THIS REPLACEMENT.

The problem before the ecologist in this country is thus rendered very complex and difficult, since his business lies in attempting to solve the natural relations of living things to their habitats (1). Had civilised man been long enough in possession to adapt the entire surface to the ideals of the radical economist, and to completely obliterate the state of things that

held sway before the axe, fire and the plough began their work of destruction and regeneration, ecological problems would be limited to the regenerative process, and field work could but advance somewhat on the lines along which the agricultural specialist and forester are now proceeding.

We happen, however, to retain sufficient remnants of the original vegetation and fauna to stimulate the desire to understand what their natural relations were before the present-day disturbing influences fell upon them, and in these we possess an inheritance rich in scientific prospect, which should not be left to be buried under the inevitable encroachment of the utilitarian and the pioneer principles of civilisation.

But it may be argued that many of our scientists are ever occupied in studying the distribution of the British flora and fauna. Have we not county lists of distribution dealing with the major divisions of our species? Have we not first-rate text-books with accurate descriptions of the species and their habitats? Have we not, further, the results of research in the laboratory and on experimental plots? This is all true and greatly to the credit of the workers in the various departments, and no one more than the field ecologist should value the works of the physiologist and systematist, and the county floras and faunas.

The writer, however, in common with other ecologists, feels that something further is needed to unravel the network of natural relationships in the field, the synecology as additional to the autecology, and it is with the hope of stimulating study in this direction that the present article is written. The old method of recording distribution by counties and vice-counties, in spite of its admitted usefulness, needs reinforcing by a more studied attempt at a true ecological distribution. The county-list method gave no adequate idea of the original distribution of plant associations, and endemic plants and colonists received almost equal recognition through its columns. One county-list might be mainly constructed from natural associations, and a second from plantations, hedgerows and cultivated ground.

The county-list method gave, in fact, no true idea of the present distribution. A species of plant, mollusc, or insect might occur only at one spot in one county, and be widely distributed in another, and yet both counties would be equally recognised. The truth, of course, is that counties are absolutely artificial boundaries for any type of natural association, and as indices of distribution will always be of comparatively little value for scientific purposes. What about the comparison of counties that are all cultivated with others all moorland, midland counties with maritime ones, mountainous counties and lowlands, counties without lakes with those dotted all over with them?

It is true that the habitats and life-histories of individual species of plants and animals are becoming more closely studied, and have recently become a valuable feature of our text-books. Our real field naturalists have also discarded the county method for others in which natural boundaries, such as watersheds, are used, especially in their relations to river basins or to climate, but the advance of ecology demands that we should aspire to a still more intimate and inclusive knowledge of distribution in regard to life association.

Alike in plant ecology and entomology, as examples of ecological studies, we want to know the sum of plant and insect associations on each as nearly natural habitat as can still be found, with their ecological relations both biological and physical. We want to grasp and to be able to describe, before it is too late, the present range of such habitats and their probable extension in the past. The value of the results that would accrue from a study of the chalk grassland, taken in conjunction with its entomology and malacology, must be perfectly clear to any field naturalist, and the same may be said in regard to our southern natural beech forests. The plant and animal associations of each of these habitats are almost completely natural and strongly interwoven and self-supporting, but to a marked degree independent of the surrounding associations as regards their species. The same applies to the coastal sand dunes, though differences in geographical relation, and the migratory coastal nature of the formation, have resulted in variations in the types of plant and animal association in the north, south-east and west. The fens and the reed-belt are also famous for the close restrictions of their species, while the northern and southern heaths and the moorland have wider developments of associated floras and faunas.

How then may we map out the country for the purposes of the ecologist? The divisions given in the *Types of British Vegetation* (2) form an excellent beginning so far as the plant basis is concerned, but the writer is prejudiced in favour of a more natural if rather more complex classification, in which physiographical factors are given greater importance, such as was recently outlined in the *Scottish Botanical Review* (3).

The fieldsman beginning such studies will probably find a working knowledge of natural history and physiography the most useful weapon. His first need is to distinguish natural from artificial conditions, and here a knowledge of physiography is his mainstay; while the detection of the natural or artificial association of the various forms of life depends chiefly on his field experience of natural history. A simple classification of habitats is into:

- (1) *Artificial*, such as we find in plantations, hedgerows, gardens, fields, railway cuttings and embankments, quarries, and other types of

made ground. But a proper knowledge of physiography and natural history enables the fieldsman to detect much finer degrees of interference such as may be passed over by one who lacks this knowledge, and so we have as a second group—

- (2) *Altered* by drainage, burning, stocking with animals, planting and cutting timber, mowing grass, or from the action of smoke cloud. The results of such interference may merely cause a preponderance of certain species or natural types of association, or may lead to new or secondary associations having an approach to the artificial.
- (3) *Natural*, which may be further subdivided into (1) *Stable*, those that are comparatively stable and carry such vegetation as moor, wood, heath and certain types of grass in this country. (2) *Migratory*, where geological or animal factors locally dominate the station and induce such vegetation as marsh, fen, alluvial grassland, bushswamp, etc. (3) (4).

The naturalist naturally searches places where he obtains the greatest number of species in the least area, and these are almost always occupied by groups of migratory formations. Stable formations yield comparatively few species after the first mile or so has been exhausted. This not only applies to the plants but also to the smaller and less active species of animals; but the rich places are generally mixtures of many plant and animal associations.

3. THE PROBABLE EFFECT OF MAN'S INTERFERENCE ON THE DISTRIBUTION OF SPECIES.

There are three phytogeographical regions in this country—

- (1) Arctic-Alpine Region—the sanctuary of plant formations from former more widely extended arctic-tundra and alpine provinces. The region is very limited at present, and the plant associations chiefly migratory.
- (2) Moorland Region—the stronghold of plant formations isolated through the influence of an acid humus barrier.
- (3) Mesophytic Forest Region—occupying most of the area where the above humus barrier is ineffective or wanting in the Mesophytic Forest Province.
- (4) A Steppe Region is wanting in Britain (3).

The stable or regional types of vegetation have overlapped on to the same areas during postglacial times, and this is believed (5) (4) (3) to be due to repeated secular shiftings in the boundaries of the climatic provinces. A

cold steppe climate may have invaded this country in late glacial times, but since then the climate appears rather to have shown alternating phases that were (1) of a more insular moorland type, cold and humid with rather equable summer and winter temperatures and atmospheric precipitations, or (2) of a more continental forest type with heavy seasonal precipitations, warmer, drier summers and frosty winters with longer snowlie. The former would favour the moorland type of vegetation and accumulation of humus, but with lower temperatures during such a phase an approach to tundra conditions would have occurred.

The continental phases, on the other hand, favoured a forest vegetation in the lower-lying and sheltered districts, and an alpine vegetation on the higher mountain slopes and summits.

Repeated insular or moorland phases have resulted in a gradually increasing accumulation of humus to form the humus barrier aforesaid. The continental phases, on the other hand, have tended to destroy the humus barrier.

On the whole, the moorland phases have prevailed in the north and west, since the humus barrier has become widely established there, even at low levels, but steep sheltered slopes have provided a retreat for a subalpine forest vegetation, while a precipitous topography at high elevations has afforded a sanctuary for a truly alpine vegetation.

In the lowlands of the south and east the continental phases have prevailed, since the humus accumulation is but local, and woodlands have been enabled to retain wide possession, but certain areas of porous soils and isolated eminences have suffered such prolonged leaching that heath has locally become the dominant vegetation on a sparse, raw humus soil (6).

The moorland phases resulted in a widening of the humus barrier, a general retreat of the forests and an advance of the moorland, a partial substitution of lowland forest by subalpine forest, and a retreat of the true alpine flora to the steepest topography where humus accumulation was delayed. The continental phases, on the other hand, caused a removal of peat from steep surfaces and exposed tops at high altitudes, a retrogression of the plateau peat mosses into bog and their invasion by pine forest and *Calluna* moor, an expansion of the lowland forest and a limitation of the subalpine forests to the mountain slopes and western coastal regions subject to the moistest climate.

Each recurring moorland phase has doubtless favoured alpine colonisation by the cold-tundra and acid humus-dwelling species like *Salix herbacea*, *Loiseleuria*, *Arctostaphylos alpina*, *Empetrum*, *Vaccinium* *Vitis-idæa*, and *Betula nana*, since some of these species became widespread on the plateau

peat mosses during such phases, but it has also restricted the range and curtailed the number of species of the alpine incapable of competing with acid humus-dwelling plants, and those requiring snow cover or protection from growth stimulus in winter-time, and greater warmth and light in the summer season. In other words, the wet moorland phases favoured the humus-dwelling alpine and arctic types, while the drier continental phases would favour the more delicate alpine that shun competition with humus plants and are chiefly chomophytes, or mesophytes, so far as their soil requirements and underground organs are concerned.

As a further result of these regional changes of plant associations, there were doubtless changes in the constitution and distribution of our country's fauna, a waning or expansion in the distribution of the smaller species depending on forest and alpine, or moorland and arctic-tundra, conditions, as the case might be, and various migrations amongst the larger forms. One at least of the latter, the Irish Elk, became extinct before historic times.

Before the advent of civilisation the country was, therefore, chiefly moorland in the north and west, with certain alpine formations in the higher parts of the mountains. Birch woods, pine woods, and various types of northern and western heaths flanked and dissected the areas where the formation of peat was prevalent. The oak forest, which occupied nearly the whole of the lower ground to the south and east, gave place to woodlands with a dwarf type of "sessile oak" and birch in steep subalpine districts of the moorland exposed to the Atlantic type of climate. On the other hand, in the drier eastern lowland areas, the oak forest gave place to what has been termed "dry oak wood," also with *Q. sessiliflora*, but with a different ground flora, wherever the porous condition of the soil or rapid drainage resulting from the nature of the physiography had led to leaching of the surface; and this in turn to various forms of heath where, from the dominating sterility of the ground, the oak was unable to obtain a footing. Ash woods were dominant on subalpine valley slopes where limestone was the rock basis. The chalk downs were occupied by chalk grassland. Beech woods, though now so widely distributed on well-drained, firm surfaces of rock, stiff boulder clay or other consolidated deposits, were originally almost restricted to certain slopes of chalk and other limestones in the south of England (2).

But besides these stable or regional types of plant association so dependent on geographical and climatic conditions, we had others more dependent on locally recurring specific conditions in their habitat which, I have suggested, should be grouped together under the name Migratory Formations. These also are usually segregated by geographical boundaries,

but are further limited by the specific conditions mentioned below. They include various formations limited to the stream and coastal belts, or to the foci where the physiography curtails vegetation and prevents full stabilisation owing to its influence on drought, wind exposure, low temperatures, or the instability of surface incurred through gravitation. Thus we have various alluvial grasslands, marshes, fens, reedswamp and aquatic formations with those of shingles, sand dunes, mudflats, crags, scree, etc.

The truly alpine formations are, therefore, for the most part migratory, at least in this country, while the sub-arctic peat mosses and the plant associations of the semi-desert alpine plateaux are more of the nature of outliers of the circumpolar tundra. But the latter, in this country, also chiefly owe their persistence to purely local migratory factors.

To these migratory formations, as limited above, must be added others where distinctly local changes occur in the vegetation as a result of repeated interference by animals. We may thus define the migratory formations as resulting from markedly local disturbances in the more stable types of vegetation leading to displacement of their associations by others which followed in the track of the geological agents of surface change, or on that of the more social animals, including primitive man, who, for long ages, had formed, by their pathways and places of congregation, the specialised haunts of various parasites, weeds and camp-followers.

The migratory formations included plant associations with differences in the history of their segregation. Thus they provided sanctuaries for plants ousted by other plant associations advancing with a change of climate. These formed relict associations from past conditions, when they had a wider range of distribution. Others formed outposts for pioneer plants attempting to invade the country from the coast-line, or by lines of migration along the river-belt. A third, and more inclusive group, was formed of plants peculiar to the various classes of migratory habitat.

There can be little doubt that the associated insects and other invertebrate creatures also formed defined groups of species which might, similarly, be divided into (1) alpine and recessive, (2) coastal species and late immigrants, and (3) species peculiar to migratory habitats on account of the nature of their food, the aquatic or other conditions of their larval stages, or from other causes.

The vertebrates too, though so often powerful migrants, were doubtless then, as now, chiefly confined to definite habitats by their food, enemies, breeding or other habits.

Many species have ceased to inhabit our islands, and the range of the survivors is, to a considerable extent, governed by artificially imposed

restrictions, or by a newly acquired licence. It is therefore probable that each type of habitat originally held a well-marked animal and plant association far more distinct than we find now.

If a patch of ground is cleared in the midst of natural vegetation of a stable type, it is rapidly invaded by plants from two quarters—(1) plants from migratory associations in the vicinity, and (2) plants from the surrounding stable associations.

Provided no further interference takes place, the plants of the stable associations may gradually oust all other competitors, and the stable formation is reconstituted.

If the interference is repeated, a number of plants from the migratory associations continue to contest the ground, and only a few of those from the stable associations obtain any footing. If the interference is periodic and of an evolutionary nature, such as only occurs where natural migratory factors are in operation, migratory associations take possession of the ground and reach that degree of stabilisation allowed by the migratory factors.

If, instead of merely a patch of ground being cleared of its original vegetation, a wide district gradually undergoes a transformation of this kind, the immigration of plants from the original stable associations is checked and eventually eliminated, and the ground which formerly supported stable associations, if left to itself, can only become clothed by types of vegetation constructed from such plants as were the least easily exterminated, or the most rapid in migration. These are essentially those of migratory formations, since their habitats are generally governed, even in the most fertile districts, by geological factors which have hindered their complete reclamation by man.

In accordance with this, we find limited artificial clearings in our moorland districts are soon recaptured by the moorland associations, while those in widely cultivated districts are often, for long periods, occupied by a motley assemblage of weeds, incapable of reconstructing any associations comparable with those of the original vegetation.

But certain types of migratory associations depend on the influence of grazing animals for their maturation and persistence to an even greater extent than on the geological factors, which were often an initial cause in their formation; and chief amongst these are types of grassland which largely owe their degree of stability of association to the constant presence of such animals. From this, no doubt, has arisen the tendency for the plant associations, which gather on the waste or fallow ground of our cultivated districts, to stabilise as some form of grassland wherever the physiography and soil allow. The evolution of some degree of stability in grassland is probably as ancient as the evolution of grazing animals, and grasslands must

therefore have formed the ultimate phase of plant succession in this country wherever the migratory factors or the physiography aided its stabilisation and hindered that of other types of vegetation.

Steep, rocky, and uneven stony surfaces have tended rather towards some degree of stability in dwarf shrub or thorn bush, since the nature of the surface, with its poverty in pasture grasses, leads to neglect by grazing animals, but forms a cover for the smaller mammals and especially birds on migration. These often bring with them the fruits which this type of vegetation (*e.g.* whitethorn, rose, sloe, rowan, elder, bramble, etc.) especially provide for their consumption, and the fruits thus sown develop into a thicket which is unattractive to the grazing fraternity, and may even form a barrier to its ingress.

When the primitive forests disappeared before the axe, many of the plants of the migratory formations, and especially those entering into the composition of grassland and bushland, acquired greater freedom. Coastal species, those of the river-belt and others, particularly the "camp-followers" of prehistoric man and the larger animals, spread widely across the face of the country to occupy the ground as patches of annual or herbaceous weeds, or to form secondary associations of grassland or bushland; and with them, in many cases, went the insects dependent on them for food, while these in turn were followed as prey by other insects, reptiles, birds and mammals.

Those species that were completely dependent on the forest for their habitat gradually became more and more restricted, and now are only to be found where remnants of their primitive forests persist. Many plants, and especially animals, that were common in the virgin forests thus became extinct, or are now looked upon as the greatest treasures of the collector, only to be obtained in certain circumscribed districts.

Others, however, appear to have been more plastic under the changed conditions owing to an innate ability to adopt a wider range of conditions of habitat and competition. Certain plants and insects were originally confined to the patches of grassland, scrub, marsh or swamp occupying the more open parts of the forests where migratory factors checked full stabilisation, and these found greater freedom for migration, and became even more widely spread on the artificially generated open formations. Many insects that are polyphagous on various bushes and low-growing plants, according to the season, were perhaps original to these habitats. Others, perhaps, evolved such habits under the changed conditions. Similar changes, too, may have induced certain insects to leave their original food plants for garden or field produce.

The surviving plants and animals mingled with other vagrants migrating from the coast-line and river-belt, and with the planted or self-sown trees

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and shrubs of our hedges and plantations, to constitute a mixed flora and fauna such as form the ground mass of many of our county lists.

An index to the solution of these problems may be looked for in any considerable patch of woodland, where it will be found that the safest guide to virgin conditions is in a combined study of the plant and animal association. The virgin forest usually holds peculiar species not found in the surrounding districts, whereas plantations are, for the most part, free from such associations, but contain a number of otherwise plastic, but shade-loving, species which are widely scattered through the country.

Some insects are now found wherever their food plant is established, and these can be shown in certain cases to be habitual migrants. Others are aliens by derivation, and not rarely of the nature of insect pests that particularly infest areas where crop-plants are closely grown in quantities for economic purposes.

4. ECOLOGY THE PROPER METHOD FOR RECORDING DISTRIBUTION.

How then can we extricate our plant and animal associations from this complex of confusion? We should cease from merely recording the presence of a certain species in this and that county. We must ascertain the headquarters of a virgin flora and fauna and set ourselves to master the relations of the associations, looking, in the meantime, on those plants and animals that have adopted the new conditions as "weeds" and "camp-followers," only to be traced to their place of origin after the main framework of the original associations has been established.

The faunal and floral relations of our moorland, heath and chalk grassland, should be acquired with the greater precision since they have been the least altered, and their associations cover the widest areas. Next in order would come the migratory formations most resistant to reclamation, as those of the blown sand and the reed-belt, salt marsh and aquatic habitats. In our forest formations we unfortunately can but hope to pick up the remnants of a vast bygone, while our fens are only too well known for the numbers of their extinct plants and animals. Many of the migratory formations, such as the grasslands, marshes, bushswamp and scrub, and especially the "camp-followers," have to so marked a degree sent out their invading hordes into the great artificial complex, owing to the prevalence of fertile open formations and the rapid and extensive dispersal artificially provided, or have in themselves been so altered by drainage or other interference, that the task of solving their original relations is beset with great difficulty, but, as the other associations become better known, much can perhaps be done for them by the process of elimination.

For the plants, a beginning has been made in the *Types of British Vegetation* and other papers of British plant ecologists. As to the fauna, the strength of the argument should, I think, appeal to any true field naturalist who has a fair acquaintance with entomology. The published lists of distribution, moreover, clearly indicate the wide opening in this kind of investigation.

We cannot give here detailed examples of plant and animal association, because none has yet been worked out with sufficient thoroughness. As an example of a study of the distribution of British freshwater mollusca on modern ecological lines, a paper "On the Geographical Distribution of Mollusca in South Lonsdale" may be noted (7). In America the study of animal ecology is being prosecuted with vigour, and a number of papers have already been published (8).

Numerous insects, arachnids, crustaceans, worms and protozoans are aquatic in some or all of their life stages. All these, of course, are limited to the neighbourhood of various aquatic formations, and while the larger forms and predatory species are often powerful migrants by land, air, or water, others are unable to stem the slowest stream, or bear for the shortest periods any but the moistest atmosphere. A wide range of distribution is therefore to be expected amongst aquatic species, and especially those of amphibious habits. As in the case of all animal associations, the most highly organised forms usually acquire the widest range of habitat, and may form a component in several different associations of the lower forms of life. The various species of waders, ducks, gulls, auks and divers affect very different stations during their summer residence, and in this they appear to be equally guided by their nesting habits and their food supplies. Their presence reacts powerfully upon the vegetation of their stations and on the other faunas. Even so restless a creature as the Dipper is almost confined to certain reaches of the stream-belt, the Kingfisher to others, while the Otter may be met with from mountain tarn to river mouth and sea-worn cave.

Many insects, like the *lepidoptera*, are limited by the distribution of a food plant, but that this is by no means the only factor involved is shown by a comparison of the distribution of the various insects and their food plants. The *lepidoptera* of our sheltered woods, when compared with those of exposed situations like the moorland, differ as much in habits as in protective adaptations, and all have adopted food plants peculiarly prevalent in their associations. There is little doubt that all the principal plant formations have peculiar species of insects to be unravelled by the ecologist. As random and isolated instances, the "wainscotes" of our reed-belt and coastal formations, the "crimson underwings" of our oak forest, and the

numerous day-flying moths of our heaths and moors are well-known examples.

But several of our smart *Vanessæ* have obviously been "camp-followers" and powerful migrants from a distant period, and chose as food plants the weeds that crowd upon the heels of our cattle, and those, moreover, that none but themselves can touch with impunity. Our gorgeous "yellows" and "whites" are, in this country, fed at man's expense, and they the most notorious of migrant hordes. The little *Davus* still, however, flits the northern moors with his dingy suit of sable; *Blandina* haunts the remnants of the sheltered moorland birch woods, simulating in his feeble flight and dusky colour his cousin of the southern birch heath. Many other insects too, peculiar to the moorland, have yet escaped the gradual but fatal advances of the fire and drain.

The insects of our chalk downs, where neither fire nor drain can reach, are exceptionally blessed, as all observers who have dwelt much in moorland districts can aver. Here the lovely "blues" reign over a kingdom rich in old-established associations, and attest the comparative harmlessness of sheep where artificial interference fails.

The more highly organised forms of a natural association do not, indeed, merely take toll without helping towards its security as such. The wild boars that formerly rooted in our woodlands are believed to have been active agents in the regeneration of the ancient forest. Wolves kept the weaker grazing animals, so injurious to seedling trees, from undue increase, and chiefly restricted their wanderings to the open downs and uplands. Horned cattle owned the alluvial meadows, borders of the marshes and the woodland flushes, trampling all that obstructed them in browsing, and thus helping, in the yearly death and destruction, the harvest claimed by autumn floods.

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VII.—Note on the Morphology of the Heart of Vertebrates.

By J. Graham Kerr.

(Read 24th February 1913. Received 10th March 1913.)

IN this note I use the expression "primitive cardiac tube" or "primitive heart" to signify that portion of the original ventral or subintestinal vessel which is included within the limits of the pericardiac cavity. In the lowest Gnathostomata, what is ordinarily called the heart in the adult represents this primitive cardiac tube in a modified form, whereas in the higher vertebrates the "heart" represents only the posterior portion of the primitive cardiac tube, its anterior portion having lost its rhythmically contractile coat of striped muscle fibres, and forming simply the root portion of the great arteries. In trying to get his ideas clear regarding the precise method in which this modification of the anterior portion of the primitive cardiac tube has come about, the morphologist finds himself hampered, as is so often the case, by confusion arising from want of precision in the use of technical terms.

We may take it as generally accepted that the vertebrate heart is morphologically a portion of the primitive ventral or subintestinal vessel, in which a local enlargement of the muscular wall is accompanied by a concentration of the contractility which originally expressed itself in the form of peristaltic waves passing from behind forwards over the whole length of the vessel. This locally enlarged piece of vessel is contained in a special coelomic chamber, the pericardiac cavity, which it traverses in an antero-posterior direction, and which, in the lowest existing Gnathostomata (Elasmobranchs), is surrounded by a rigid unyielding wall.

The primitive heart as it develops undergoes not only increase in thickness but also increase in length, and this, owing to the fact that in the primitive gnathostome the two ends of the cardiac tube are fixed by being firmly embedded in the surrounding tissue, has caused the tube to become curved. The early stages of this curvature are well known—the first stage, easily observable in the embryo of most Vertebrates, consisting of a simple bulging towards the right side, and this simple curvature passing gradually into a double curvature in which the tube assumes a roughly S-like form.

By the appearance of constrictions, or more precisely, by the cardiac tube increasing less rapidly in thickness at certain levels than it does elsewhere, the S-shaped tube loses its uniform diameter and becomes converted into the set of chambers arranged in series—*sinus venosus*, atrium, ventricle and *conus arteriosus*—characteristic of the heart of the primitive gnathostome.

There exists an unfortunate confusion regarding the nomenclature of the parts into which the anterior end of the cardiac tube develops. The science of morphology being in its very essence an evolutionary science, we are compelled, in accordance with its general principles, to found our interpretation of the structure of the more highly evolved forms upon the facts of structure of the more nearly primitive forms. Similarly, we must base our nomenclature, which is merely the verbal expression of homology, upon the conditions met with in the more primitive forms. The most nearly primitive of the Gnathostomatous Vertebrates are, as is almost universally admitted, the Elasmobranch Fishes, and probably even those morphologists who are inclined to minimise the claims of this group to the title primitive will admit that, so far as heart structure is concerned, they are more nearly primitive than other Gnathostomes. Now the nomenclature of the parts of the heart in these fishes is perfectly clear. The part of the heart which specially concerns us here, the part which passes forward from the ventricle to the anterior limit of the pericardiac cavity, is what Gegenbaur christened *conus arteriosus*.¹

This name is generally accepted by workers on the anatomy of Fishes, and we are therefore, in my opinion, bound to accept it for the homologous structure in Vertebrates above Fishes, in spite of the fact that the name was originally borrowed from a not necessarily homologous structure in the heart of man.² The *conus arteriosus* of the Elasmobranch is the morphologically anterior portion of the primitive cardiac tube: it is intercalated between the ventricle and the ventral aorta. The structural characteristics of the primitive conus which mark it off from the ventral aorta in front of it are two in number. (1) Its endocardiac lining is thickened to form cushion-like longitudinally arranged ridges (frequently four in number) which project into its lumen; and (2) its muscular wall contains striped muscle fibres which, like those of the rest of the heart, are rhythmically contractile. The primitive

¹ 1866, *Jenaische Zeitschrift*, ii. p. 374. Joh. Müller had already shown (Dec. 1844, *Abb. Berlin Akad. Wiss.*) that, under the name *bulbus arteriosus* (the name given at that time generally to the structure lying in fishes between ventricle and ventral aorta), there were included two physiologically different organs—the organ bearing that name in Elasmobranchs and Ganoids being physiologically a part of the heart, rhythmically contractile like the rest of that organ, possessing striped muscle fibres in its wall and containing valves in its interior, whereas the similarly named organ in the Teleost was merely a part of the ventral aorta, becoming passively dilated on the contraction of the ventricle, containing no valves in its interior, and possessing only smooth muscle fibres in its walls.

² Cf. 1894, Langer, *Morph. Jahrb.*, xxi. p. 42. The chief objection to using the term *bulbus cordis* for this part of the heart is its similarity to, and therefore liability to be confused with, *bulbus arteriosus*. The whole point in Gegenbaur's giving it a special name was to distinguish it sharply from the *bulbus arteriosus*.

conus which has just been defined is clearly an apparatus for the prevention of regurgitation of blood into the ventricle during the diastole of the latter. The systole of the ventricle is followed by that of the conus, the effect being to jam together the endocardiac ridges so as to obliterate the lumen, and in this way effectively to prevent any sucking back of the blood when the ventricle again dilates. This primitive condition of the conus persists among the Gnathostomata at the present day only in the embryos of various Vertebrates.

In tracing out the further evolution of the primitive conus we may distinguish two main processes at work. Firstly, we see a continuation of that process which, in the first instance, led to the marking off of the primitive heart from the rest of the ventral vessel—the greater localisation of the power of rhythmic contraction. The primitive conus, the front part of the primitive cardiac tube, loses its rhythmic contractility from before backwards, its striated muscle becoming replaced by smooth muscle fibres, and, in fact, its general histological structure becoming like that of the ventral aorta.¹

Secondly, we see that the physiologically elaborate neuromuscular apparatus for preventing regurgitation from ventral aorta into ventricle becomes replaced by a simple, purely mechanical and automatic, and therefore more reliable, arrangement of pocket- (semilunar) valves. In Elasmobranchs it can still be seen in ontogeny how each longitudinal ridge becomes segmented up to form a row of pocket-valves. In Crossopterygians (*Polypterus*—and no doubt in Actinopterygian Ganoids also, although in them the ontogenetic development has not yet been worked out) a similar process takes place, each longitudinal ridge being represented by a longitudinal row of pocket-valves in the adult.

One of the points of this note is to accentuate the morphological importance of these ridges or rows of valves, as marking morphologically longitudinal lines on the conus wall and thus affording invaluable landmarks in studying the processes of folding and twisting which this part of the heart has undergone during the evolution of the higher groups of Vertebrates. Individual ridges may, in particular animals, be discontinuous. In the Amniota, for example, each ridge is represented either temporarily or during the whole of its existence by two distinct rudiments, one anterior and one posterior. Whether or not this discontinuity is, as I am inclined to believe, secondary,

¹ The observed facts are susceptible of being interpreted, as they are by Greil (1903, *Morphol. Jahrb.*, xxxi., etc.), as being due to an actual backgrowth of the ventral aorta or truncus at the expense of the conus. Looking to the fact, however, that the cardiac tube is firmly fixed in position at its point of exit from the pericardiac cavity, it seems to me reasonable to regard the structures lying between this and the ventricle as homologous in the various groups whatever their histological condition in the fully developed state.

there seems to me no sufficient reason to doubt that the ridges were originally strictly longitudinal in position.

The great importance of the Dipnoan heart as an aid to the comprehension of the morphology of the heart of the tetrapod Vertebrates has long been recognised, *e.g.* by Boas¹—perhaps the most clear-sighted worker in this department of morphology. Here, in addition to Boas' results, I shall make use of the excellent study of the structure and development of the heart of

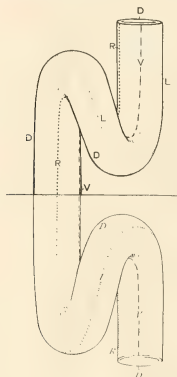


FIG. A.



FIG. B.

A. View of a piece of flexible tubing bent so as to illustrate the flexure of the cardiac tube in Dipnoi. The part of the figure above the horizontal line represents the conus as seen from the ventral side. The original dorsal (D), ventral (V), right (R), and left (L) surfaces are indicated by longitudinal lines.

The part of the figure below the horizontal line represents the hypothetical similar curvature of the atrioventricular portion of the primitive cardiac tube.

B. Represents the portion of tube above the horizontal line in Fig. A after it has been straightened out so as to have a right-handed spiral twisting distributed throughout its length.

Lepidosiren which has recently been carried out by Dr Jane Robertson.² The first important point about the Dipnoan conus is that in *Ceratodus* one (the originally right-hand ridge), and in *Lepidosiren* and *Protopterus* two (the originally right-hand, and also the originally left-hand), of the longitudinal rows of pocket-valves have reverted towards the ancestral condition of a continuous ridge projecting into the lumen of the conus. This is one of those cases constantly turning up in embryology and comparative anatomy which

¹ 1880, *Morph. Jahrb.*, Bd. 6.

² 1913, *Quart. J. Micr. Sci.*, N.S., vol. lix.

make the "Law of the Irreversibility of Evolution," enunciated by Dollo¹ and generally accepted by palæontologists, so puzzling to the morphologist. Using the longitudinal ridges as landmarks in the way already indicated, it becomes clear that in *Lepidosiren* (as in *Ceratodus*—Boas) the conus has—no doubt owing to its increase in length within the confined pericardiac space—become bent twice upon itself in the way indicated in the accompanying figure (upper part of Fig. A).²

It will be seen that the result of this double flexure, combined with the fixation of the cephalic end of the conus, is that the hinder end of the conus has been forced into the position that it would have had if the conus had undergone a process of twisting in a counterclockwise direction (as seen from behind) through an angle equal to three right angles. It is also evident that were the tube figured to shrink in length, so as to straighten out the two kinks, such a spiral twisting would become apparent distributed throughout the length of the conus—the spiral being a right-handed one, as shown in Fig. B. If we suppose the cavity of the front end of the tube (*i.e.* the part which retains its original position in relation to the body) to be divided by a horizontal partition into a dorsal and a ventral cavity, then that one of the two cavities which is at the headward end dorsal in position, will at the hinder end of the tube be on the right side, and the partition will now be vertical, its originally left-hand edge being now dorsal, and its originally right-hand edge being now ventral.

In the higher Amniota, *e.g.* in a Mammal, the portion of the primitive cardiac tube lying between the ventricle and the headward limit of the pericardiac coelome, and therefore homologous with the *conus arteriosus* of the Elasmobranch, takes in the embryo the form of a gently curved tube which develops in its lining the usual four longitudinal endocardiac ridges. Of these the morphologically right (Ridge 1 of Boas) meets and fuses with its *vis-à-vis* (Ridge 3 of Boas) so as to divide the cavity by a "pulmonary aortic" septum. In this case the septum eventually splits, so that the primitive conus becomes resolved into completely separate pulmonary and aortic vessels. The longitudinal ridges of the Amniota are seen at their first appearance to describe a spiral course, so that the conus has the appearance of being twisted in a right-handed spiral, and the same, of course, holds with the resulting vessels which twist spirally round one another. It is always

¹ 1893, Bull. Soc. Belge de Geologie, etc., vii.

² The fact that the two longitudinal limbs of the conus have slipped into a position somewhat dorsal to the middle limb is probably due to the pericardiac space being limited in width and depth as well as in length. Obviously the three limbs pack together more compactly than they would if the curvature were all in one plane. This relative position of the three limbs of the conus is of importance in connection with what follows.

puzzling to try to understand how the twisting of a tubular organ about its longitudinal axis has come about in evolution. One always feels inclined to ask the question whether the spiral twisting may not be a secondary result of some simpler process, such as mere uniform growth in length. An explanation of this kind seems to hold in the case of the apparent twisting of the intestine in the lower Fishes, which has arisen from a spiral coiling of the gut brought about by increase in length within a limited space. Such a question arises in the case of the spiral twisting of the conus and its derivatives in Amniota, and it is, I think, adequately met by assuming that the Lung-fishes retain an ancestral condition of the conus from which that of Amniotes (and Amphibians) has been derived. It is of interest to note that distinct vestiges of the double flexure of the conus appear to occur in Amniotes. Thus Greil has shown how in *Lacerta*¹ the "bulbus" (*i.e.* conus) goes through a "bayonet-shaped" stage, and Hochstetter finds a still more strongly marked double flexure, like that of a Lung-fish, appearing as a transitory phenomenon in the heart of the crocodile.²

What I suggest, therefore, is that in the common ancestral form from which Amphibians and Amniotes have been derived, there was present an elongated *conus arteriosus* folded in a double fold just like that which is still present in existing Lung-fishes, that during the evolution of the Tetrapods there has taken place a relative shortening of the conus (associated probably with the concentration of the valvular apparatus into a relatively short anteroposterior extent), and that the result of this shortening has been to straighten out the bends of the conus so as to convert it into a nearly straight tube, with a spiral twist about its long axis.³ This has split up, of course, later in the higher Amniota into separate vessels twisted spirally round one another.

I have taken it for granted that the anterior and posterior ends of the primitive cardiac tube are fixed in position, being firmly embedded in tissue, and this carries with it the necessary consequence, already perceived by Boas,⁴ that any twist in the anterior portion of the tube must be neutralised by an equivalent twist in the contrary direction in the hinder part of the

¹ 1903, *Morph. Jahrb.*, Bd. xxxi.

² 1906, Voeltzkow's *Reise in Ostafrika*, Wiss. Ergebnisse, Bd. iv.

³ It would appear from Boas' papers that he looks upon the double flexure of the Lung-fish conus as having come about subsequent to the spiral twist, the already twisted conus having become "zusammen-geschoben" so as to produce the flexure (*Morph. Jahrb.*, vi. pp. 326, 327, 332). Similarly the twisted conus of higher forms would be derived from a spirally twisted conus which had not developed the double flexure (*Morph. Jahrb.*, vii. p. 511).

⁴ *Morph. Jahrb.*, vi. p. 332.

tube. Unfortunately, in attempting to examine into this part of the problem, we are handicapped by the fact that the endocardiac swellings of the atrio-ventricular part of the tube are in the form rather of isolated cushions than of longitudinal ridges; but we are probably fairly safe in assuming that the left-handed twist, which must necessarily be present in this part of the heart, even though not visible, came about in evolution by a similar process of folding to that by which we have explained the twisting of the conus region. To what extent this primary flexure of the atrioventricular portion of the heart is represented by the flexure which occurs during early stages of ontogeny is a question of much interest, but one which is not easy to answer definitely on account of the difficulty already alluded to.

(Issued separately, 21st May 1913.)

VIII.—Obituary Notice of Ramsay H. Traquair, M.D., LL.D.,
F.R.S. By Percy H. Grimshaw, F.R.S.E., F.E.S.

(*With Plate.*¹)

(Read 24th March 1913. Received 22nd March 1913.)

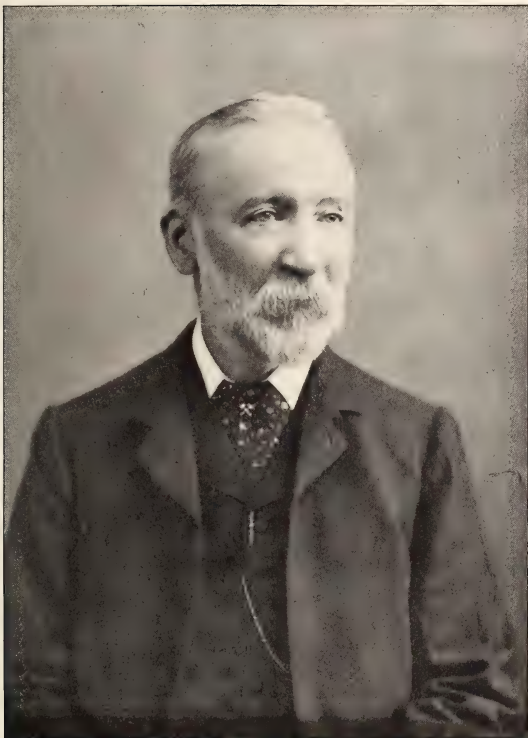
ON the 22nd November last the Royal Physical Society of Edinburgh lost one of its three oldest Fellows. Dr Ramsay Heatley Traquair, whose lamented death occurred on that day, was elected a member of the Society on the 23rd November 1859, and thus, by a melancholy coincidence, was taken from our midst within a few hours of the fifty-third anniversary of his admission to Fellowship. During this long period Dr Traquair ever showed a keen interest in the Society, taking an active part in all its proceedings, and serving in an official position almost without interruption. Indeed, between the year 1863, when he was elected a member of the Marine Zoology Committee, and that of 1908, when he finally retired from the Council, the only break in his service as an officer of the Society occurred in the eight years from 1866 to 1873, when he resided in Cirencester and Dublin.

From the following list of the positions held by the Doctor, one may imagine to what extent the Society must have benefited from its long and intimate association with a man of his scientific attainments:

Elected member, 23rd Nov. 1859.	Councillor, 1879-1880.
Member of Marine Zoology Committee, 1863-1865.	Librarian, 1880-1881.
Member of Library Committee, 1863 and 1866.	President, 1881-1884.
Councillor, 1864-1865.	Councillor, 1885-1887.
(Left Edinburgh in 1866 and returned in 1873.)	Secretary, 1887-1888.
Councillor, 1874-1876.	President, 1888-1891.
President, 1876-1879.	Councillor, 1891-1894.
	Secretary, 1895-1903.
	Vice-President, 1903-1905.
	Councillor, 1906-1908.

The proceedings of the Society bear strong evidence of Dr Traquair's scientific activity, and of the esteem he felt for the Society itself. Obviously, he regarded the Society's Journal as a most suitable medium for his writings, for some of his most important discoveries were first communicated to the scientific world through the agency of its pages. Out of some 133 memoirs, it is gratifying to know that no fewer than 31 were published in the *Proceedings* of the Royal Physical Society, amounting in the aggregate to over 260 pages.

¹ For the use of the block which illustrates this Paper the Society is indebted to Dr Henry Woodward.



Yours sincerely
RH Traquair.

Ramsay Heatley Traquair was born at Rhynd in Perthshire on 30th July 1840. His early education was received in Edinburgh, whose University he afterwards entered as a student of medicine. He graduated there in 1862, receiving a gold medal for his thesis, the subject of which had an intimate relationship to the work of his after life. The researches involved in this memoir, which was on the "Asymmetry of the Pleuronectidæ," probably struck the key-note to which his life-long studies were attuned, for we find him ever afterwards regarding the skeleton of the fish, especially when fossilised, as the subject most worthy of his attention. Although the various official positions he from time to time occupied necessitated the enlargement of his horizon, yet we find him returning again and again to his favourite subject. This remarkable singleness of purpose, coupled with his brilliant powers of research and deduction, led to his rapidly becoming one of the most distinguished authorities in his own line of investigation, viz. Palæichthyology, and it is no exaggeration to say that his careful and laborious work completely revolutionised the classification and nomenclature of the earlier investigators. His numerous discoveries among the fossil fishes of his native country have proved of inestimable value to the zoologist and geologist alike, for they have thrown a flood of light, in the first place, on the relationships and systematic position of several extinct families, and, secondly, on the age of the various strata containing their remains.

A word should be said, too, on the important work he accomplished while occupying the chief official position of his life, namely, that of Keeper of the Natural History Department in the Edinburgh Museum of Science and Art, afterwards the Royal Scottish Museum. Being the first to occupy this post, he laid the foundations of the scientific arrangement of the important collections in this Museum, inaugurating a type-collection for University and other students which has proved of the utmost value. In classifying the general collections on exhibition, one of the main ideas which the Doctor always laid stress upon was that fossil remains were to be regarded from the zoological or botanical point of view rather than from the geological. Perhaps his most important achievement during his term of Keepership was the formation of an exceptionally fine collection of fossil fishes, chiefly from the older Scottish rocks—a collection which, for its local value and interest, is probably second to none.

Apart from his special knowledge and qualifications Dr Traquair possessed a remarkable general knowledge. He was keenly interested in Lepidoptera, especially exotic butterflies, and this is reflected to some extent in the fine Museum collection formed under his care. He was a fine linguist, and exhibited a strong partiality for the German language, literature, and people.

His artistic powers were unusually well developed, and this faculty enabled him to draw with his own hand many of the illustrations which accompany his published memoirs. His artistic temperament also shone forth in another way, for he was a musician at heart and possessed considerable skill as a pianist.

Lastly, an extreme absorption in his work, often leading to an utter obliviousness to his surroundings, an irrepressible abhorrence of anything savouring of quackery or humbug, and an unusually developed critical faculty, were always strong personal traits in the doctor's character. Such a nature is at times apt to be misunderstood, and no doubt such was the case with many who met our late friend and colleague. But those who really knew him found in Ramsay Heatley Traquair a true and genial friend and adviser, one who invariably compelled respect and admiration, and one whose memory we shall always hold in affectionate regard.

(Issued separately, 22nd May 1913.)

IX.—**Scottish National Antarctic Expedition—"Scotia" Collection of Fishes from St Helena.** By R. S. Clark, M.A., B.Sc. (Carnegie Research Scholar, 1912-13), Scottish Oceanographical Laboratory, Edinburgh.

(MS. received 13th January 1913. Read 24th February 1913.)

THE 23 species here recorded were taken by the "Scotia" during a short stay at St Helena on her return voyage from the Antarctic. Though all have been previously described, yet, as a result of this capture, four now fall to be included in the fish fauna of the island.

These are—

Gonorhynchus greyi.

Exocætus speculiger.

Thynnus pelamys.

Sargus rondeletii.

Little importance can be attached to the occurrence of *Exocætus speculiger* and *Thynnus pelamys*, as these are typical open Atlantic forms and widely distributed, though their appearance at this island seems rare.

As Mr J. T. Cunningham (1) has already stated, the fish fauna of the island is extremely interesting owing to its wide relationships. Its members show affinities with the fishes from Ascension, Cape Verde Islands, Madeira, Azores, and the Mediterranean; and also with those from Brazil and the West Indies, and from the Cape of Good Hope.

To Dr Harmer, Keeper of Zoology, British Museum, I wish to express my indebtedness for granting me all facilities to compare my material with the type specimens; and also my cordial thanks to Mr C. Tate Regan, whose method of description I have adopted throughout, for kindly assisting me in the identification of several of the species, and for personal supervision of my work.

The following are the "Scotia" species, with a detailed description of two—*Gonorhynchus greyi* and *Synodus synodus*.

***Gonorhynchus greyi* (Richardson).**

Depth of body $7\frac{2}{3}$ to 10 in the length; length of head $4\frac{2}{3}$ to $5\frac{1}{3}$. Snout $1\frac{3}{4}$ to $2\frac{1}{5}$ as long as diameter of eye, which is $4\frac{1}{2}$ to $5\frac{1}{3}$ in length of head; interorbital width 4 to 5. Lips fringed and papillose; barbel reaching margin of upper lip. Gill rakers, 12 to 15 in lower anterior arch.

Dorsal 11 to 12; first ray three-fifths of second, which is about two-fifths length of fourth; fourth and fifth rays the longest, $1\frac{2}{3}$ to 2 in length of head.

Origin of dorsal almost above end of base of pelvics. Anal 9 to 10. Origin of anal equidistant from base of pelvic and base of caudal.

Pectorals $1\frac{1}{3}$ to $1\frac{1}{2}$ in length of head; second and third rays the longest. Pelvics $1\frac{1}{2}$ to $2\frac{1}{3}$ in length of head. Caudal emarginate. Caudal peduncle $1\frac{3}{4}$ to $2\frac{1}{3}$ as long as broad.

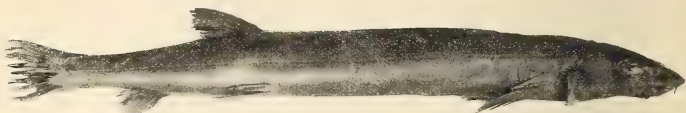


FIG. 1.
Side view of *Gonorhynchus greyi*.

170 to 200 scales in a longitudinal series; 20 to 21 between origin of dorsal and lateral line. Body yellowish brown—darker above than below. Scales, especially above the lateral line, with minute dark spots. Fins, except caudal, with terminal black spots, margined with white. Caudal with central black blotch.

Description based on 6 specimens, 289 mm. to 437 mm. in total length.

These include specimens from New Zealand, Tasmania, West Australia, Cape of Good Hope and St Helena. The "Scotia" collection is represented by 1 specimen, 338 mm. in total length, from St Helena.

A list of measurements in millimetres is added to show individual variations.

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>
Length to base of Caudal	403	371	338	286	279	260	268
Length of Head	80	79	69	55	52	54	63
Length of Snout	34	32	28	22	21	21	26
Length of Eye	15	16	13	12	11	12	13
Interorbital width	16	17	15	13	13	13	16
Length of Pectoral	55	59	48	44	39	42	50
Length of Pelvic	38	37	36	30	28	29	26
Length of longest Dorsal Ray	40	41	40	31	29	30	33
Length to origin of Dorsal	277	244	230	197	196	183	194

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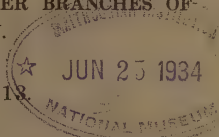
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- ¹ *a* Specimen from False Bay—Cape of Good Hope.
b " " East London, Cape Colony.
c " " St Helena—"Scotia."
d " " New Zealand.
e " " West Australia.
f " " Tasmania.
g *Gonorrhynchus abbreviatus* Schlegel (*Fauna Japonica*).

The measurements of *Gonorrhynchus abbreviatus* Schlegel, are placed alongside the others. There seems very little of a distinctive character except the longer pelvics. The number of scales in a longitudinal series is 165. The dark extremities of the fins seem to be deeper in colour, while the caudal has a black spot on each lobe.

Synodus synodus (Linnaeus).

Saurus synodus Cuv. & Val.

Depth of body $4\frac{2}{5}$ to $5\frac{3}{5}$ in the length; length of head $3\frac{1}{2}$ to $3\frac{4}{5}$. Snout $1\frac{1}{2}$ to $1\frac{3}{4}$ as long as diameter of eye, which is $5\frac{4}{5}$ to $6\frac{3}{5}$ in length of head; interorbital width $7\frac{1}{2}$ to $8\frac{1}{2}$. Upper jaw projects slightly. Premaxillary $1\frac{2}{5}$ to $1\frac{1}{2}$ in length of head. Teeth in both jaws in a double row, lanceolate, and with a tendency to arrow-shape. Teeth alternately long and short, especially in upper jaw. Palatine teeth much more slender and in several rows; inner rows longer, anterior teeth largest. Tongue covered with retrorse teeth.

Top of head striated; the striations few and very pronounced. Supra-orbital bones prominent and slightly striated.

Gill rakers reduced to rows of minute teeth.

Dorsal 14-15. Origin of dorsal just behind base of pelvic.

Dorsal fin equidistant from tip of snout and root of caudal; fourth ray the longest, $2\frac{1}{5}$ in length of head. First dorsal ray two-thirds length of the fourth; subsequent rays diminish in length. Adipose very small. Distance from adipose to root of caudal three-fifths distance from adipose to base of dorsal. Anal 9-10. Length of base half the length of dorsal base. Pectorals $2\frac{4}{5}$ in length of head. Pelvics eight-rayed; sixth ray the longest, which is seven-tenths length of head. Caudal forked.

60 to 62 scales in a longitudinal series; 5 between origin of dorsal and lateral line.

¹ *a, b, d, e, f, g* are British Museum specimens.

Body and fins speckled dark grey on a silvery grey background ; black spot on shoulder and on tip of snout ; several indistinct and irregular cross bars on the body. Description based on six examples, 244 mm. to 274 mm. in total length. The Indo-Pacific form (*Saurus varius* Günther) is closely allied to this species, but differs in having longer pectorals and pelvics, fewer dorsal



FIG. 2. *Synodus synodus*.

Reproduction of coloured drawing by Mr Cuthbertson—from fresh specimen.



FIGS. 3 and 4.

Side view of two specimens of *Synodus synodus*.

and anal rays, body more elongate, and coloration lighter. *Saurus meleagrides* Val., from Buenos Aires, is also nearly related. The pectorals are longer, and the dorsal and anal rays are different. It is figured in D'Orbigny's *Voyage dans l'Amérique méridionale*.

There seems sufficient proof that the "Scotia" specimens are identical with those described from St Helena and from Bahia by Cuvier and Valenciennes.

The following are a few of the measurements of the specimens in millimetres, to show individual variations :—

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>
Length to base of Caudal	254	253	250	250	245	226
Length of Head	72	64	70	69	67	59
Length of Snout	19	18	18	17	16	15
Length of Eye	11	11	12	11	10	10
Interorbital width	8	9	8	7	7	7
Tip of Snout to origin of Dorsal	101	103	105	100	100	89
Length of Pectoral	28	29	28	26	25	24
Length of Pelvic	53	56	55	53	46	45
Length of Præmaxillary	48	43	47	46	43	38

Aulostoma coloratum Müll. & Trosch.

2 specimens, young and adult, taken off St Helena, 171 mm. and 566 mm. in total length.

Exocætus obtusirostris Günther.

Dorsal 13; anal 13. Depth of head equal to distance from extremity of snout to hind margin of præoperculum. Snout $\frac{3}{5}$ diameter of eye, which is $3\frac{1}{2}$ in length of head. Origin of dorsal opposite origin of anal.

1 specimen, total length 137 mm.

Exocætus speculiger Cuv. & Val.

Depth of body 6 in the length; length of head $4\frac{2}{5}$. Snout equal to diameter of eye, which is $3\frac{1}{2}$ in length of head; interorbital width slightly more than diameter of eye.

Dorsal 10; first pectoral ray over half the total length of the pectoral fin, which reaches just beyond the extremity of the dorsal. Anal 11. Origin of anal slightly in advance of the dorsal. Pectoral on upper side blackish, with an oblique white band and white margin. 1 specimen, total length 240 mm.

Holocentrum longipinne Bl. Schn.

Several specimens averaging 230 mm.

Epinephelus ascensionis (Osbeck).

1 specimen, total length 203 mm.

Rhypticus saponaceus (Bl. Schn.).

Dorsal III 23. Anal 16.

The maxillary in this specimen reaches to two-thirds diameter of eye.

Priacanthus cruentatus (Lacép.).

First few dorsal spines rather low. Last spine twice as long as the second. All are strongly spinulose. Rays not much larger than longest spines.

2 specimens, total length 210 mm.

Sargus capensis Smith.

Several specimens, total lengths 232 mm. and 280 mm.

Sargus rondeletii Cuv. & Val.

2 specimens, total lengths 176 mm. and 205 mm.

Chætodon sanctæ helenæ Günther.

A painting of this specimen by Mr Cuthbertson, the "Scotia" artist, represents the colour of the body as a light lavender, which becomes darker towards the vertical fins. A narrow yellow band runs from the supra-orbital along the dorsal fin, across the caudal, and ends at the origin of the anal. The soft dorsal and anal fins have a thin black margin.

Cossyphus pectoralis (Gill).

1 specimen, total length 255 mm.

Scarus strigatus Günther.

Several specimens averaging 350 mm.

Caranx dentex (Bl. Schn.).

1 specimen, total length 594 mm.

Caranx sanctæ-helenæ Cuv. & Val.

Numerous young specimens.

Trachynotus glaucus (Linn.).*Lichia glauca* (Linn.).

1 specimen taken off St Helena, total length 333 mm.

Scomber colias Gmelin.

Scomber pneumatophorus De la Roche.

Several specimens, young and adult.

Thynnus pelamys (Linn.).

1 specimen, total length 424 mm.

The Belted Bonito has a wide tropical and sub-tropical distribution. It has been recorded from Luce Bay in the South of Scotland.

Thyrsites prometheus (Cuv. & Val.).

1 specimen, total length 285 mm.

Scorpæna mellissii Günther.

1 specimen, total length 217 mm.

Scorpæna scrofina Cuv. & Val.

Several specimens, 249 mm. to 305 mm. in total length.

Tetrodon sp.

Probably *T. cutaneus*, but too mangled for identification. This was found in the stomach of *Thynnus pelamys*.

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(Issued separately, 23rd October 1913.)

X.—Note on a case of Mitotic Division in *Amoeba proteus* Pall.

By Lucy A. Carter, S.N.D., B.Sc. Research Student, Glasgow University.

(MS. received 21st March 1913. Read 24th March 1913.)

INTRODUCTION.

IT has long been a matter of much regret that the complete life-history of *Amoeba proteus* has not been worked out during the many years it has held so important a position in the laboratory work of students of zoology. Isolated experiments have been performed, and short papers have been written upon isolated facts in the life-cycle of forms which are acknowledged by their authors to be not certainly *A. proteus*. This leads to confusion, and the extent of this confusion can only be realised by a student who takes up the subject with an earnest desire to follow the consecutive stages in the life-history of this organism.

Stolc¹ has published papers upon the origin of the multinucleate forms of *A. proteus*, which entailed the noting of over 250 divisions, but gives no particulars of the cytology of it. Calkins² wrote upon specimens prepared by his class students, finding a case of "full mitosis," which, it is to be regretted, in no way agrees with what is put forward in this note, though one is tempted to think, with Calkins himself, that sections might have made things clearer, especially in his Taf. 3, fig. 14. The only worker who has described in detail and figured mitotic division in *A. proteus* is Awerinzew.³ In his preliminary note in 1904 he compares the division with that described by Schaudinn⁴ for *A. binucleata*, with which, again, the following description cannot be said to agree in all respects.

The great variety of opinions, not merely as to facts of the life-history only, but even as to the appearance of *A. proteus*, indicates the need for still further investigation of this much-investigated type. The following note refers to one of the results of an extended research upon *A. proteus* which has been going on for nearly three years, with the assistance of the Carnegie Trust. The particular specimen referred to here answers well in general appearance to the description given by Leidy, and figured by him in his plates I. and II., with the exception of fig. 7,

¹ *Archiv. für Entwicklungemech. der Organism.*, xxi. Band, 1 Heft. 1906, p. 111.

² *Archiv. für Protistenk.*, Bd. 5, p. 1.

³ *Zool. Anz.*, Bd. xxvii., Nr 12/13 1904, p. 399.

⁴ "Über die Teilung von *A. binucleata* Grub." Sitz-Ber., *Ges. naturf. Freunde.*, Berlin, 1895, pp. 130-141.

pl. II.: its endoplasm is clear and limpid, containing large crystals which are for the most part bipyramidal; its nucleus, in the resting condition, is similar to that figured by Leidy¹ and also by Calkins²; and it feeds voraciously upon diatoms (Figs. 1 and 2). This is a point of physiological interest, as the other so-called types of this species do not so feed.

MATERIAL.

The material in which the specimen was found was obtained in December 1912, from Mr T. Bolton of Birmingham, to whom I had described the various types, remarking upon the one required. He found this latter, living as a persistent culture of its kind, in a pond at Lapworth, and he has supplied me with this single type regularly for months.

About the end of December I was on the look out for cysts, of which I had obtained a large number in the early part of that year (February 1912), consequently each incoming supply was watched with more than usual care. On 2nd January 1913, the amoebæ were covering themselves with debris and diatoms—a phenomenon which precedes encystment. This I had watched in single cases in the previous November, and since the amoebæ emerged from these little nests, instead of really encysting, I termed this temporary retreat a “pseudocyst.” During this month of November, I had turned out several amoebæ from these pseudocysts; but on one occasion, while being closely observed after such a proceeding, the amoeba was seen to divide, the whole process taking about fifteen minutes; but during this time the nucleus was not visible, owing to the density of the protoplasm in its contracted state, and to the presence of numerous food particles. A few minutes after the daughter-amoebæ had snapped asunder, a nucleus, typically *proteus*-like, was seen in each. In no case of division—and several now have passed under my observation—have I yet seen the living nucleus in the state of mitotic division; however, Awerinzew³ states that he has seen every important phase in such a division, in the living organism.

After such an experience, the presence of pseudocysts in January would have suggested division had I not been expecting the amoebæ to encyst. A few buried amoebæ were isolated in a watch-glass with water-culture, diatoms, and a small amount of debris—an inducement to encystment—and left in a quiet undisturbed condition for a few days, in a fairly constant

¹ Fresh-water Rhizopods of North America, 1879.

² Calkins, *loc. cit.*, plate 3, fig. 13.

³ Awerinzew, *loc. cit.*

temperature of 60° F. On returning to examine what I hoped would be perfect cysts, I found instead a mass of amoebæ, and before ten days were over the numbers had increased to hundreds. Division had evidently been taking place; consequently, a great number of preparations were made, with a memorandum to examine for stages in nuclear division, especially in the sectioned specimens. No case of mitotic division was found in any of the numerous whole preparations, and only the one figured in this paper was found among the sections.

This particular specimen, differing in no external respects from its neighbours in the same section, was, as they also were, slightly smaller than the ordinary extended *A. proteus*, being roughly 150 μ . in diameter.

When in an almost spherical condition and about to divide, the amoeba puts out short blunt pseudopodia, very slowly, all round its body, lengthens slightly (cf. Fig. 2), and about fifteen minutes after this first indication of lengthening—as mentioned above—the final strand of protoplasm snaps across and the two daughter-amoebæ move away from each other. This is well to remember, as to fix an amoeba when the bridge of protoplasm is already formed entails a fruitless search for mitotic figures. The capture must be made before the roughly spherical form is lost, and during the first indications of lengthening, since the mitosis is apparently at its height by this time.

THE NUCLEUS.

Before proceeding to a detailed description, it might be a help to the correct reading of the figures, to state that the nucleus in question has been sectioned somewhat obliquely, as is clearly shown by a reconstruction with glass plates. This obliquity affects the appearance of the sections, but particularly that shown in Figs. 2 and 2a, giving a false impression as to the position of the apices of the cones of the spindle; the first section of the series, which shows no portion of the spindle, is not figured.

Contrary to Awerinzew's¹ account, the nucleus has not assumed the form of an Ellipsoid of Rotation, the flattening, if such there be, has taken place in a plane parallel to the spindle axis and not at right angles to it.

Apart from the fact that it is in the metaphase of mitosis, the condition of the nucleus as a whole is remarkable. The persistence of the nuclear membrane in its entirety is interesting, as Lawson² holds that this

¹ Awerinzew, *loc. cit.*

² *Trans. Roy. Soc. Edin.*, vol. xlviii., part 1. (No. 7), p. 140.



FIG. 1.

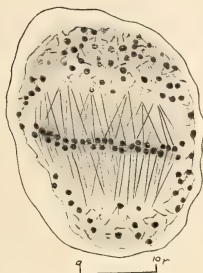


FIG. 1a.



FIG. 2.

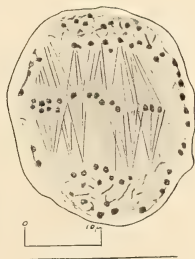


FIG. 2a.

FIG. 1. Section through *Amoeba proteus* to show position of nucleus.

FIG. 1a. Nucleus of Fig. 1 on larger scale.

FIG. 2. Next section of series.

FIG. 2a. Same as Fig. 2 on larger scale.

Drawings of Figs. 1 and 2 were made under objective D and ocular 12 (Zeiss), while those of 1a and 2a were made under oil immersion $\frac{1}{2}$ and compensating ocular 12—all with the aid of an Abbe's camera.

The sections were cut 5 μ thick in paraffin and celloidin, and stained on the slide in Ehrlich's hæmatoxylin.

persistence occurs in all cases of mitosis, and that the apparent absence of the nuclear membrane in preparations is due to the destructive action of fixing agents; but his view that the nuclear membrane contracts around each individual chromosome obviously does not hold good for *Amoeba*.¹

The spindle itself appears to be multiple in character, imperfectly divided into a number of constituent spindles, each one of which has its axis parallel to the long axis of the nucleus. These elementary spindles are arranged side by side, in a row which is perpendicular to the long axis of the whole nucleus, and extends practically throughout its whole width. Whether the centrosome apparatus is diffuse or, on the other hand, multiple, with a distinct centrosome at each spindle apex, cannot be made out with certainty in the preparation.

The number of elementary spindles appears to be four or five, the limits of the two at the right edge of the section (Fig. 1a) being difficult to define, but the one at the extreme left of section (Fig. 2a) stands out most distinctly, leaving practically no doubt of the plurality of spindles.

The equatorial plate is distinctly seen under a very low magnification, while under high powers the chromosomes can be counted, although, owing to the oblique plane of section, there is occasionally a certain amount of indefiniteness of outline and consequently of individuality.

Another result of the obliquity is that the spindle with its chromosomes appears in two sections, and the sparsity of the chromosomes in the second (Fig. 2a) shows that, had the plane of the sections been absolutely parallel to that of the central axis, one section would have enclosed the whole of the equatorial plate with its spindle fibres. This proves clearly the statement, already made, that the spindles are arranged not around a central axis but in a row 20μ in length and having an average breadth—from apex to apex of the spindles—of 15μ , the multiple spindle thus forming a band about 4.5μ thick lying in the nucleus. This might suggest, perhaps, a possible explanation of peculiar appearances often occurring in the nucleus of whole preparations of *A. proteus*.

The chromosomes of the equatorial plate have evidently just passed through the process of division, as the separated daughter-chromosomes are distinctly visible at the bases of the spindle fibres. As already mentioned, a glance at the section (Fig. 1a) under low and moderately high powers gives the impression of four or five spindles, each spindle carrying about ten daughter-chromosomes, giving roughly 50 chromosomes.

¹ *Trans. Roy. Soc. Edin.*, vol. xlviii., part 1 (No. 7), p. 144.

Careful examination under very high powers appears to confirm this, as the number of chromosomes which can be counted in Fig. 1a is 32, and in Fig. 2a is 17, bringing the number very near to 50; but the arrangement into *five* spindles is less pronounced in Fig. 1a owing to the apparent crossing of the fibres, which is not seen under low magnifications.

The chromosomes, if such they can be called, are small masses of chromatin, about $1\ \mu$ in diameter; their outline is somewhat indistinct but apparently approximately spherical in shape. Of their progressive formation to build up the equatorial plate, nothing can be said with certainty from this one case, but there seems to be a fair agreement with Awerinzew's¹ description of the breaking-down of the large granules in the resting nucleus before the appearance of the chromosomes. He mentions, however, a polar plate outside the nucleus, with a polar cap composed of the remaining nuclear protoplasm. Both these appear simultaneously with the differentiation of the spindle fibres. Of the extra-nuclear polar plate there is no evidence whatsoever in the nucleus here described, and while it is true that the cytoplasm surrounding the nucleus has been unfortunately torn away in both sections, there is no indication within the nucleus of any such polar plate having been present. As to the remaining nuclear substance, there is a certain amount all round the spindle next to the membrane. Within this, fragments and reticular strands lie diffusely scattered. The former stain with hæmatoxylin in a similar manner to the chromosomes, with which many of them agree in size, while others are larger. This staining material is thicker at the poles, and gives, on reconstruction, the impression of a polar cap containing the chromatin which has not been used up in the formation of the mitotic spindle.

The work on *Amoeba proteus*, during the course of which this case of mitotic division has come under my notice, is being carried out partly in the Zoological Laboratory of the University, and partly in that of the College of Notre Dame, Dowanhill.

¹ Awerinzew, *loc. cit.*

XI.—On *Thanasimus rufipes*, Brahm., a Beetle new to the British Fauna, and its Life-History. By Professor T. Hudson Beare, B.A., B.Sc., M.Inst.C.E.

(Read 27th January 1913. Received 21st June 1913.)

IN the early part of last July, during a visit to Nethy Bridge, Inverness-shire, I was trying to capture *Magdalis duplicata*, Germ., by beating the cut-off tops of felled Scots firs, and on 15th July, when examining the contents of the net after a pretty vigorous thrashing of a lot of tops, I saw amongst the debris of pine needles and swarms of common insects two specimens of *Thanasimus*. I was just about to turn them out, thinking they were both our well-known species *formicarius*, L., when, fortunately, certain differences in their general appearance caught my eye, and both specimens were bottled. Upon killing and mounting them, I found that one was *formicarius*, L., and the other an insect which differed in certain important characters from that species. On my return to Edinburgh in September, this species was soon identified as *rufipes* Brahm., the only other European species of the genus. This species is apparently rare on the Continent in central and northern regions, though it is also recorded from Spain.

The discovery of such an interesting addition to our fauna induced me to have a look through my boxes of duplicates of captures at Nethy Bridge in 1910 and 1911, and to examine my diaries for these two years. In 1911, I was apparently too late for the insect, and none was seen, but in the 1910 diary I found a record of a capture of one specimen of *Thanasimus*, on 9th July, and, on overhauling the duplicate box for that year, the species proved to be *rufipes*. At the time it was taken, I naturally assumed it was *formicarius*, set it, put it away, and never looked at it again. I captured altogether, in 1912, five specimens; the last one was taken on 6th August. There can, therefore, be no doubt that the species is truly indigenous, and its probable rarity is the reason why it has escaped notice.

T. rufipes differs from *formicarius* in its smaller size—6.8 mm. as against 7.10 mm., and in the much finer and less dense puncturation of the head and thorax; moreover the whole of the breast of *formicarius* is black, while in *rufipes* only the metasternum is black.

In typical *rufipes* the antennæ and legs are red, and in *formicarius* they are black, but in *rufipes* var. *austriacus* they are partly black, and in *formicarius* var. *laticipes* they are mainly red.

In *formicarius*, the elytra, with the exception of a narrow red band at their base, are black, and the black portion is traversed by two transverse

bands or fasciæ of white pubescence. In *rufipes*, the basal red portion extends much farther down the elytra, and in the type form the basal transverse white band crosses this red portion of the elytra—in fact it divides the red portion from the black portion. It was this striking difference in the colour pattern of the elytra, and the smaller size, which caught my eye when the two specimens were together in the net on 15th July.

There is a var. of *rufipes*—*femoralis*, Zett.—in which the white bands are arranged as in *formicarius*.

The Nethy Bridge specimens have the antennæ and legs in part black, and they are, therefore, apparently the var. *austriacus*, Reitt.

The life-histories of most of the European species of the family *Cleridæ*, to which the genus *Thanasimus* belongs, are fairly well known.

The larvæ of the various species of *Trichodes*, for example, are parasitic upon the domestic and certain wild bees, and are exceedingly destructive; on the other hand the larvæ of the species of *Thanasimus*, and several other of the allied genera, render most useful service to man, as they are the deadly foes of many of the insects injurious to forest trees.

The larva of *formicarius* has been described by Erichson, Perris, Ratzeburg, and others, and its life-history is well known. I have found this larva (or possibly the larva of *rufipes*) under the bark of Scots fir at Nethy Bridge. The full-grown larva is elongate, somewhat thickened towards the hinder third; it consists of 12 segments, and in colour it is dark pink with the head and prothorax pitchy, and two pitchy spots on the meso- and meta-thorax. The head is almost as broad as the prothorax, horny, with a forked sutural line in the centre; there are 5 ocelli, and the antennæ are short and two-jointed. The prothorax and the dark spots on the meso- and meta-thorax are horny, and there are two small roundish horny plates on the last segment, which end in a pair of hooks directed outwards. The legs are moderately long, three-jointed, terminated by a simple claw, and are bright brown in colour.

The larvæ are full grown in late summer or early autumn, when they pupate, and the imago usually remains in its cell till the following spring, but may emerge at once. The imago is found both in late summer and in early spring, more commonly at the later period, running on fir tree trunks on sawn timber, or on faggots and boughs of felled trees; it is exceedingly active and wary and difficult to capture; it does not, however, fly.

It is an exceedingly rapacious insect, feeding on *Scolytidæ* and other allied beetles; it holds its prey by means of its front legs, and, biting the prey in the softer integuments between head and thorax, sucks the juices of the captive. If two specimens are placed together in a collecting bottle

they will at once attack and mutilate one another, and I have often seen a specimen of this rapacious species seize another beetle in the collecting bottle and tear it to pieces.

It is more difficult to observe the habits of the larva, as it lives exclusively under bark, but it undoubtedly feeds upon *Scolytidæ* and other bark-frequenting insects, and upon their larvæ and pupæ, as it constantly occurs in the runs of *Scolytidæ*.

Ratzeburg reared many specimens in captivity, and was able to verify these facts; he thought the larvæ might also possibly feed on the vegetable debris produced in making the burrows and passages they construct in order to chase their prey.

Though I sought for larvæ after finding the imago last July, I was unsuccessful, but I hope during the coming summer to make an attempt to rear some larvæ in captivity, with the object of ascertaining if there is any structural difference in the larvæ of the two species, or in their life-history.

Ratzeburg in his *Forst Insecten*, vol. i, p. 35, deals with the life-history of *formicarius*, and rightly includes it under the group of useful forest insects; though it is difficult to find the larvæ, the extraordinary abundance in which the imago sometimes appears is a testimony to the important part these insects play in the maintenance of an adequate check upon the destructive species of the *Scolytidæ* and other foes of our forest trees.

XII—Notes upon some Rare New Zealand Birds, and Exhibition of Skins, Skeletons and Eggs. By Symington Grieve.

(Received 25th March 1913. Read 24th March 1913.)

THE Kiwis are perhaps the most interesting group of birds to ornithologists, and, as there is a danger that the species may become extinct, it is desirable that every scrap of information about them, and their habits, should be put on record.

Perhaps *Apteryx haasti*, of which specimens are on the table, is now extinct, and, if not, it is upon the verge of extinction. When I was in New Zealand in 1889, it was the impression among a number of naturalists that only one skin was known and that was in the Museum of Natural History at Dunedin. I was always doubtful as to whether such information was correct, and I believe one or more specimens of *Apteryx haasti* were to be seen in the fine collection of New Zealand birds in the museum at Canterbury, even at that time. The mistake probably arose through a confusion in the nomenclature, as the name by which I heard these birds called was *Apteryx grandis*, which I understand has been identified as the same as *Apteryx haasti*, the latter being the name by which it is now known.

It appears it is limited to a comparatively small area in the South Island, while its smaller congener, the *Apteryx oweni*, has a wider distribution and is much less rare.

However, all these birds are now great rarities, and, owing to the necessary restrictions put upon their capture by the New Zealand Government, it is most difficult to obtain specimens.

I may say at once, that in acquiring these specimens it was for no private purpose; but with the object of enriching a public scientific collection in Scotland. They have now been presented, along with a number of other New Zealand birds, to the Royal Scottish Museum of this city. I hope before long they will be suitably mounted and be on exhibition in approximately natural surroundings.

It is questionable if we have heard the last about the naming of the various Kiwis. However, the following may now be considered as accepted names, which are likely to continue to be recognised by scientists:—

Apteryx haasti from South Island, *Apteryx australis* from the South Island and Stewart Island, *Apteryx mantelli* from the North Island, and *Apteryx oweni* from both the North and South Islands, with a variety of *A. oweni* named by Rothschild *A. occidentalis*.

I am not sure that any other names that have been given to possible varieties of these birds will for long stand the test of scientific investigation.

The late Professor Alfred Newton and Dr Hans Gadow, in their *Dictionary of Birds*, published in 1896, page 496, Note 2, say: "*A. maxima* (from Stewart Island), *A. haasti*, *A. mollis* and *A. fusca* have also been indicated, but proof of their validity has yet to be adduced." This shows that the learned Professor had some doubt in his mind regarding *A. haasti* even in 1896.

However, there were so few specimens known at that time, that in all probability he had never had the opportunity of examining a skin or skeleton of *A. haasti*.

In *Novitates Zoologicae*, vol. vi. p. 366, the Hon. Walter Rothschild, Ph.D., says: "Sir Walter Buller, having received a large female from Stewart Island, considered it different from *A. australis*, and applied to it the name of *A. maxima*. This name not being applicable, I named it *A. lawryi* in honour of Sir Walter Lawry Buller. Having now before me a good series of *A. australis* from the South (or middle) Island, as well as from Stewart Island, I find that, although the largest females happen to be from Stewart Island, they cannot be separated—the majority of the specimens being equally large from both localities. In addition to this, we find similar variations in size among *A. australis mantelli* from the North Island."

Apteryx mollis appears to have originated (Potts, *Trans. and Proc., New Zealand Inst.*, vol. v. p. 196, 1873) from an albino specimen of *A. oweni* obtained at Martin's Bay, West Coast.

Apteryx fusca (1875, Rowley in *Ornith. Misc.*, vol. ii. p. 8) named from a dark-coloured specimen of *A. oweni* by mistake.

Newton and Gadow say (*Dictionary of Birds*, p. 496): "The Kiwis form a group of the sub-class *Ratitae*, to which the rank of an Order has been fitly assigned, as they differ in many important particulars from any of the other existing forms of Ratite birds. The most obvious feature the *Apteryges* afford is the presence of a back toe, while the extremely aborted condition of the wings, the position of the nostrils—almost at the tip of the bill—and the absence of an aftershaft in the feathers, are characters nearly as manifest, and others not less determinative though more recondite will be found on examination. The Kiwis are peculiar to New Zealand."

The Kiwi was first described by Shaw, and figured in 1813 (*Nat. Miscellany*, pls. 1057, 1058) from a single specimen obtained on the South Coast of New Zealand. It afterwards formed part of the bird collection

of the thirteenth Lord Derby, and is now with the rest of that collection in the museum at Liverpool. *It is a skin of A. australis.* As some doubted the existence of such a bird, Lord Derby, on 12th February 1833, exhibited his unique specimen at a meeting of the Zoological Society, London. A few months later, Yarrell submitted a complete description of it (*Trans. Zool. Soc.*, vol. i. p. 71, pl. 10).

In 1838, Professor Owen published a monograph in *Trans. Zool. Soc.*, vol. ii. p. 257; vol. iii. p. 277.

Shortly after 1847, another Apteryx was discovered to which Gould gave the name of *A. oweni* (*Trans. Zool. Soc.*, vol. iii. p. 379, pl. 57).

In 1850, Mr Bartlett, after careful examination, expressed the opinion that differences existed between certain examples, which had all been considered as belonging to *A. australis*. His investigation led him to think that two species had been confounded. To the second of these, the third of the species, he gave the name of *Mantelli* (*Proc. Zool. Soc.*, 1850, p. 274). Shortly afterwards, it was discovered that to the new form the most of the specimens already obtained belonged. Professor Newton states that in 1850 only two specimens of *A. australis* were known. In other words, most of the specimens had been obtained in the Northern Island, to which *A. mantelli* appears to be restricted; just as *A. australis* is believed to be only found in the Southern Island and Stewart Island.

The first live specimen to reach Britain arrived in 1851, and was a specimen of *A. mantelli*, which was presented to the Zoological Society of London by the Lieutenant-Governor of New Zealand. Careful observation was kept of its habits in captivity, and the results published by Newton and Wolley (*Zoologist*, pp. 3409, 3605): "In the year 1859 she laid her first egg, and has continued to lay one or two more every year since that time. In 1865, a male bird was presented by Henry Slade, Esq. During the last year these birds showed symptoms of a desire to pair. This was known by the loud calling of the male, which was answered by the female in a much lower and shorter note. They were particularly noisy during the night, but altogether silent in the day-time. On 2nd January the first egg was laid, and for a day or more the female remained on the egg; but as soon as she quitted the nest the male bird took to it, and remained constantly sitting. On the 7th of February the second egg was laid, the female leaving the nest as soon as the egg was deposited." "The male continued to sit in the most persevering manner until 25th of April, at which time he was much exhausted, and left the nest. On examining the eggs I found no traces of young birds" (A. D. Bartlett, *Proc. Zool. Society*, 1868, p. 329).

Sir W. Buller (in his *Birds of New Zealand*, 2nd ed., vol. ii. p. 313)

thus describes his observations upon the habits of *A. mantelli*:—"The Kiwi is in some measure compensated for the absence of wings by its swiftness of foot. When running it makes wide strides and carries the body in an oblique position, with the neck stretched to its full extent and inclined forwards. In the twilight it moves about cautiously and as noiselessly as a rat, to which, indeed, at this time it bears some outward resemblance. In a quiescent posture the body generally assumes a perfectly rotund appearance, and it sometimes, but only rarely, supports itself by resting the point of its bill on the ground. It often yawns when disturbed in the day-time, gaping its mandibles in a very grotesque manner. When provoked, it erects its body, and, raising the foot to the breast, strikes downward with considerable force and rapidity, thus using its sharp and powerful claws as weapons of defence. . . . While hunting for its food, the bird makes a continual sniffing sound through the nostrils, which are placed at the extremity of the upper mandible. Whether it is guided as much by touch as by smell, I cannot safely say; but it appears to me that both senses are used in the action. That the sense of touch is highly developed seems quite certain, because the bird, although it may not be audibly sniffing, will always first touch an object with the point of its bill, whether in the act of feeding or surveying the ground, and when shut up in a cage, or confined in a room, it may be heard, all through the night, tapping softly at the walls. . . . It is interesting to watch the bird in a state of freedom, foraging for worms which constitute its principal food; it moves about with a slow action of the body; and the long flexible bill is driven into the soft ground, generally home to the very root, and is either immediately withdrawn with a worm held at the extreme tip of the mandibles, or is gently moved to and fro by an action of the head and neck, the body of the bird being perfectly steady. It is amusing to observe the extreme care and deliberation with which the bird draws the worm from its hiding-place, coaxing it out, as it were, by degrees, instead of pulling roughly or breaking it. On getting the worm fairly out of the ground, it throws up its head with a jerk, and swallows it whole."

Sir W. Buller, also at page 315, *Birds of New Zealand*, 2nd ed., vol. ii., gives a most interesting description of the *A. mantelli* and its habits and nesting places, in an account of a Kiwi hunt in the Pirongia Ranges. This account is reprinted in *Novitates Zoologicae*, vol. vi., December 1899, pp. 373-377.

Whether all the Kiwi family act in exactly the same way may be doubted, and we may be sure that at least to some extent the food of the species varies. Those restricted to limited areas, some of them at considerable distances from the coast and at fairly high elevations, can hardly be expected to live upon the same diet as birds living upon the lower ground.

Most of the collection now submitted was obtained by Mr James Dall, a botanist and collector of natural history, who resided at Collingwood, New Zealand, and was well known to collectors in this country, the European Continent, and the United States. He was a careful and accurate observer, and was much esteemed by those who knew him.

The first time I heard of Mr Dall was about thirty years ago, at a meeting of the Botanical Society, when a large number of New Zealand plants were exhibited that had been collected by him.

Some years afterwards, I visited New Zealand, and when at Lake Wakatipu I climbed up one of the mountains. It came on a dreadful storm of wind and rain, and, as the evening was well advanced, I was thinking of returning home. Just at that moment I saw an elderly man approaching heavily laden with botanical specimens. He had a sack upon his back, and a large satchel slung from his shoulders, besides one or more other packages attached to his person. When he came up to me, I made the remark that he was rather overburdened, which he admitted was true. I asked him where he had come from, and he told me he had been botanising at the other side of the mountain, where he had gone for some special plants that were wanted. I was greatly interested as I did not expect to come across a botanist in such an out-of-the-way place. I asked him where he was going, and discovered that he was living not far from where I had my abode, which was some miles off.

I told him that I would return with him and relieve him of part of his load, for which he was very thankful. As we trudged along down the mountain side, I plied him with many questions regarding the flora and fauna of New Zealand. I soon discovered I had come across no ordinary student of natural history, so before we separated I asked his name, and found it was no other than James Dall I was speaking to. This was the beginning of my acquaintance with this interesting and remarkable man, who, without special opportunities, had made almost a world-wide name for himself as a collector.

He was known everywhere in New Zealand, and especially in the South Island, and was seldom at home. Sometimes he wrote me from Australia where he was engaged by one or other of the governments to make collections, and it was difficult to get replies to letters, until long periods had elapsed.

However, after about ten years of correspondence he collected for me a few rare specimens, some of which are before you. I wrote asking many questions, some of which were answered, and I would have liked to have had much more information. I have made extracts from his letters about *Apteryx haasti* and *Apteryx oweni*, which contain what may be worth recording. You will observe what Sir W. Buller's description is of *Apteryx mantelli*, and that

such references as Mr Dall makes are all about *Apteryx haasti* and *Apteryx oweni*.

Apteryx haasti was described by Mr Potts who died at Canterbury, N.Z., in 1888, and who was the possessor of the only egg of the Great Auk at that time in the Southern Hemisphere. That egg, I believe, is now in the collection of Col. I. E. Thayer. Mr Potts was well known as an ornithologist; what he wrote about *A. haasti* will be found in *Ibis*, 1872, p. 35; and *Trans. N. Zeal. Inst.*, vol. iv. p. 204.

Apteryx haasti.

Mr James Dall, writing me on 12th December 1894, says: "I returned from a trip a few days ago. I got a male, female, and chick of *Apteryx haasti* (*grandis*) and was particular in saving the portions of skeletons.

"I left the skeleton of the chick to drain, whilst I went to the tent for the billy, and, though not 30 yards away, on my return it was gone. A weka must have been watching me and carried it off, as though I looked well for it I failed to find it. The skeletons of the male and female I laid to one side whilst packing, and, a sudden storm coming on, the horse started off before I had the packs secure, broke all the three eggs I got during the season, and so I forgot the skeletons. The three skins are the best I got during three trips—the female especially is a very large bird. I got the male bird alive belonging to the large female; also an egg. The male bird was exceptionally small, and the egg was only half the size of one that I got; there was a chick. I blocked the hole at the mouth of the nest, climbed up the hollow tree which was leaning very much, to examine for holes and block them, as they generally have an outlet, but did not find any, so I tried to get them out. All at once I heard a noise, and the chick dropped about 25 feet. There was a large knot hole under an astelia, and he had forced himself through, and I lost it. I was two days getting the live bird out, and after I had him a fortnight he made his escape.

"The female is always the larger bird, though occasionally you get a large male with a female nearer his own size,—sometimes quite a small male, with a very large female. As I stated previously, the eggs, of which I got three only, vary in size.

"The nest is generally a few leaves of *Dracophyllum latifolium* scraped under roots or trees, sometimes on the bare ground. The habits of the bird are not known well, but, from my observations, they do not keep together in the same nest all the year, as I think *Apteryx oweni* does. Neither do they lay two eggs together as that bird does.

"The female *Apteryx oweni* sits on the two large eggs laid, but from

careful observation I don't think the female *Apteryx grandis* (*haasti*) sits on the egg at any time. When they pair, both birds keep in the same hole till the egg is laid. Whether the birds interchange places to hatch the first egg I was unable to learn. But after the chick is out, I think it goes with the female during the early part of the night to feed, but always stays in the same root (or mound), though not generally—rarely—in the same hole, as the male during the day.

"The female always goes a great distance away, and, if alarmed, I am under the impression she tries to draw you away from the nest. On being alarmed, when the chick is in the vicinity, the male bird immediately makes a loud clapping noise with his beak and the young one starts (to run), and, whilst you secure the other, he generally escapes.

"It is very cold where the birds are got, but they are in better plumage. The skins I have reserved are the best I have got. The feathers rub off as the birds run along, if they touch anything sharply, and, as they are powerful, and fight very fiercely, you can imagine how difficult it is to get good skins."

In a postscript he adds: "The male, female, and chick" (he probably means not when newly hatched) "all feed together during the early part of the evening, and perhaps during the night. When I have been very late getting to camp—as late as midnight—I have heard the three, and always hear the female. The call of the large (old) birds, females, is like distant thunder. I do not think the female sits, as I always got male on egg."

Again, writing on 10th February 1896, when sending off some of the skins and other remains collected, he says: "I have returned from my trip (collecting), during which I had such untoward weather that I was considerably longer than I expected. The first two birds *Apteryx haasti* (*grandis*) I got, I had a difficulty in getting out (of their hole); the birds striking, tore both my hands severely, so that I could not use arsenical soap or any poisonous preparation, and my man I had with me was no use for anything of the kind. In fact, after I had skeletons cleaned, he destroyed several, not seeing any use for them. My man I usually have was unable to accompany me.

"The large female skin is the finest skin I have got. The egg of this bird was one of those broken last year, and was considerably larger than the egg now sent, whilst others were smaller. The egg of *Apteryx haasti* (*grandis*) I send you is the only one I got; one of the largest males I have obtained was sitting upon it, but the skin was lost through my being unable to preserve as above described.

"From the appearance of the nest I should think it had been used twice

previously, (of this, of course, I could not be quite certain), the layers seeming to indicate that."

Mr Dall mentions that the female of *Apteryx haasti (grandis)* when captured alive with egg in the oviduct, fully formed, and sometimes in the shell, had the power of absorbing them into their system. After confining the birds for a few days the eggs appeared to dwindle away internally and finally dissolved.

Letter, 15th August 1896.—". . . The locality for the *Apteryx haasti (grandis)* is among the ranges upon the West Coast of the South Island of New Zealand. These birds feed upon worms, freshwater crayfish and snails. The dark-coloured *Helix* or *Paryphanta lignaria*, which I have never seen in a perfect state, is very abundant in the bogs or parkees where the Kiwis run.

"I have heard of extra large specimens of *A. haasti*, also of *A. mantelli (bulleri)* and *A. australis*, or giants, as it were, of their races; but the *A. haasti* sent to you is the largest I have got. These three Apteryges are indiscriminately called Roas by the Maori. It is only by exercising great care that the true species can be certified. I see no reason to doubt the truth in regard to these extra large specimens, as I know the parties who have caught them, and they are as a rule men not given to exaggeration."

Letter, 18th May 1897.—"I have only heard of two skins of *Apteryx haasti* being got since my last. The place is so difficult of access that much cannot be done that way unless at great expense."

The Hon. Walter Rothschild, Ph.D., in *Novitates Zoologicae*, vol. vi., December 1899, page 383, says: "Very little is on record about the life-history of Haast's Kiwi, but from what we know its habits are similar to those of the other species of Apteryx."

It is to be observed that when I first met Mr Dall he only knew the large Apteryx (which he later called *haasti*) by the name *grandis*, and another naturalist to whom he introduced me only knew the bird by this name and did not seem to know of *Apteryx haasti*. In his correspondence with me, he in early letters names these birds as *A. grandis*; then later on he changes to *A. haasti (grandis)*, and finally refers to them only as *A. haasti*. From this I conclude that he at least believed they were *haasti*, as he certifies them as such.

However, quite apart from what Mr Dall writes, as to the name, his correspondence makes it clear that they came from the South Island from an exact locality, which I have not mentioned. It therefore follows that, if *A. mantelli* is confined to the North Island, the remains under consideration cannot be that variety, and the skins now exhibited seem so different from *A. australis* that I do not think they are its remains. Then they are so

much larger and unlike *oweni*, that that comparison may be at once put aside.

The skins exhibited agree so completely with the published descriptions of *A. haasti*, that I think there is not the slightest doubt about their correct identification.

Dr Ernest J. O. Hartert writes me from Tring, 15th March 1913.—“Years ago the Hon. Walter Rothschild, Ph.D., had three *A. haasti* alive, and their habits did not differ from other birds of the same genus.”

Apteryx oweni.

Letter, 10th February 1896.—*Apteryx oweni*.:—“As a rule the sexes can be defined by the beaks, but in two instances I have found myself deceived. During my trip I did not get one egg of *Apteryx oweni*. I caught six birds alive, with eggs apparently fully formed, some in the shell. A few days after the birds were caught I found the eggs dwindling away and finally dissolve internally.”

Mr Dall thought there was more than one variety of *Apteryx oweni*, the larger variety being found on the Wakamarama Ranges, Collingwood, N.Z. He evidently refers to *Apteryx occidentalis* of Rothschild.

Letter, 15th August 1896.—“The egg of *Apteryx oweni* sent is of the ordinary variety, not of the larger one.”

Letter, 9th April 1898.—“I have not observed *Apteryx oweni* on the side of the range where *Apteryx haasti* is.”

Mr James Dall mentions an incident connected with the egg of *Apteryx oweni*, a skin of which is here. As you have heard, the *Apteryx* lays two eggs. In the case in question, the bird had laid one egg and was about to lay the second, when it was attacked by a dog which caught it across the loins, and must have slightly cracked the egg, as in the laying it broke in two. One half remained in the bird, causing its death. Naturally there is a suspicion that the dog had injured the bird, but Mr Dall does not seem to think so.

Apteryx australis.

The two skins exhibited are male and female. The male bird was obtained by a member of a government expedition about November 1888, when at a place in the bush near Lake Manipori in the South Island. It was killed along with a female, and the skins brought to Dunedin to be properly prepared. I heard of them, and found that the skin of the female had been purchased by a visitor from the United States. I, however, succeeded in getting the owner to sell me the skin of the male. The only other Kiwi with which *australis* is likely to be confused is *mantelli*, but as it is said to

be confined to the North Island, it cannot be the bird now exhibited. As *A. australis* is said to be the much rarer bird of the two, this skin is interesting. I may add that the gentleman from whom I purchased this skin told me that, although a wide search was being made through the bush over an extended area for a Professor of Otago University who had got lost, neither he nor his remains were ever found.

The only *Apteryx australis* seen or obtained were the two mentioned, of which the skin of the male is now here. This evidence makes it pretty clear that at the end of 1888 and beginning of 1889 the various species of *Apteryx* were getting rare in the district around Lake Manipori.

The Hon. Walter Rothschild, Ph.D., in *Novitates Zoologicae*, vol. vi., December 1899, page 366 *et seq.*, says: "*A. australis*, although the first known form of the genus, is much rarer in collections than *A. oweni* and *A. australis mantelli*, and until quite recently it was by no means easy to procure a series of this bird." "In 1888, Sir Walter Buller wrote as follows:—'Comparatively few specimens of this species are now brought in by collectors in the South Island, whereas the supply of *Apteryx oweni* is undiminished; and the conclusion is irresistible that *Apteryx australis*, perhaps the most interesting bird in the Southern Hemisphere, is fast becoming extinct.' At present, they are evidently still common in certain places, and it is strange that this fact was overlooked by collectors, who have apparently never yet systematically explored the avifauna of all parts of their country."

To anyone who has had actual experience of the denseness of the bush and the difficulty of getting through it, the wonder is that so much has been done to explore a country that is remote, and difficult, almost beyond conception, to penetrate. I have cut my way into the bush, and, when in, wondered if I would ever be able to cut my way out. When at last I succeeded in doing so, I was wounded and bleeding in hands and face, and my clothes all torn, with a good deal of my exploring enthusiasm for the time being quenched.

In November 1897, Mr James Dall captured the female *A. australis*, of which the skin is now exhibited, and it is a valuable addition to my collection.

On the same page from which the last quotation is taken, the Hon. Walter Rothschild, Ph.D., says: "Sir W. Buller does not describe the exact distribution on the South Island. It would seem, however, that *Apteryx australis* is less fond of mountainous parts than most of the other Kiwis, and that it is only known from the southern parts of the South Island. It will be seen from my synonymy that I cannot separate the Stewart Island birds from typical *A. australis*."

Continuing on page 367, the author refers to the publications of Sir

Walter Buller of the observations of one of his collectors, Mr Marklund, who gives a most interesting account of his studies of Kiwi life on Stewart Island, but it is too long for full reproduction here. He mentions that he generally found a pair of birds together in one hole, sometimes accompanied by a single young one. On one occasion he found five birds inhabiting an extensive chamber.

The old birds often make a stubborn resistance, and the first time his dog tackled one of them he got his foreleg ripped up about six inches by the bird's claws.

He says: "The favourite feeding ground of *A. australis* on Stewart Island is the summit of Table Hill, rising to an elevation of 2300 feet, which is covered with grass and stunted vegetation. In the day-time they descend about 500 feet, in order to camp in the bush, the summit not affording sufficient covert. He has never found any on the western slope of Table Hill below a level of 1000 feet; but on the eastern side the Kiwis go right down to the plain, or practically to the level of the sea. He has found them to inhabit holes among the roots of the Mutton-bird Woods."

Apteryx mantelli.

The skin of the very young chick came from the North Island, and was obtained by a correspondent of Mr James Dall. He told me that, although he knew the North Island, he had not been able to visit it for some years and, as he was getting old, he did not feel fit to continue going on long and arduous expeditions.

In some of his letters, he sent me a good deal of information about *A. mantelli* and the mode of its capture, but as he had received it second hand, I am not quite sure as to its reliability, so do not publish it.

This bird is closely allied to *A. australis*, and the Hon. Walter Rothschild, Ph.D., sometimes names it *A. australis mantelli*. It is confined to the Northern Island of New Zealand, and it supplied most of the living Kiwis sent to this country, as well as a larger number of skins than any other of the genus, with perhaps the exception of *A. oweni*. It is from the observation of this bird while in captivity that much of our information regarding the habits of the genus has been derived.

Sir Walter Buller, in the *Birds of New Zealand*, 2nd ed., vol. ii. page 315, states: "The male bird alone performs the labour of incubation and takes upon himself the entire charge of the young till they are old enough to shift for themselves. The female, without any assistance from her mate, digs or scoops out a nesting-place,—usually adapting to her requirements an existing hole or cavity in the ground—forms a rude nest, and deposits two eggs."

He thus describes the nesting-place of the Kiwi: "Near the bottom of a deep gully, completely choked with the ground-kickie (*Freycinetra banksii*), so thick and luxuriant indeed that it was a matter of difficulty to push through it at all, down among the gnarled roots of a tawhero, and quite hidden by a growth of *Asplenium bulbiferum* and other ferns, was the entrance to the Kiwi's retreat—a rounded and perfectly artificial entrance, just large enough to admit the hand. I inserted my arm to its full length, and could just reach the extremity of the chamber, which spread laterally and widened at a little distance from the mouth.

"The natives state that the Kiwi begins to lay in August, which is quite likely to be true, as the eggs must take a long period to incubate.

"It will be remembered that Mr Bartlett had a bird which sat on perseveringly from the beginning of January to the 25th of April.

"In all the eggs I opened (save one freshly laid) there was enclosed with the well-developed feathered chick a tough membranous sac, connected with the embryo and containing several ounces of yellow fatty substance (Vitellus). When all this adipose matter has been absorbed into its system, the chick having in the meantime expanded to its full size, cracks its tabernacle and comes out into the world ready for active service. It is very soon able to forage for itself, and increases rapidly in size, inasmuch as the young which I attempted to rear had more than doubled their size in six months."

He mentions that his party killed a specimen of *A. mantelli*, and that "the stomach of the bird contained, besides insect remains, a large number of the hard kernels of the taiko berry, and it seems to me that these are swallowed by the Kiwi (in lieu of quartz pebbles, which are not found in every locality) to assist the process of digestion. I have found similar kernels in the stomachs of Kiwis received from the Upper Wanganui. Among the comminuted matter, I was able to detect some very minute landshells. In the stomach of another, which I opened afterwards, I found a number of angular pieces of pebble, and others contained the hard kernels of pokaka, miro, mairi and hinau berries."

The Kiwis as a genus are nocturnal in their habits, and seem to live upon a diet which varies considerably. They have a preference for worms, but snails, freshwater crayfish, beetles, and insects of various kinds, and even seeds and fruits, are acceptable. In confinement, when they cannot have such a liberal variety of food, they seem to thrive on meat minced or ground small.

They stand cold well, and retain their health without much special care when in captivity, and the Hon. Walter Rothschild, Ph.D., says of *A. australis*: "They appear quite happy. They frequently utter their

very loud and strong cries in the evening, and it seemed the shrill note was that of the male. The cry of this form seems to be a little louder than that of *A. australis mantelli*, but otherwise the same."

He says (page 379, *Novitates Zoologicae*, vol. vi., December 1899): "One of the Kiwis in my possession destroyed her own egg, on which the male would not sit. Although Kiwis have laid eggs in England,—in the Zoological Gardens—in my own, and in the late Lord Lilford's aviaries, they have never yet hatched."

At page 386, Mr Frank E. Beddard, M.A., F.R.S., gives notes upon the anatomy of the genus *Apteryx*. I cannot go into particulars, but would refer anyone interested to this communication. However, Mr Beddard mentions the discovery of a remarkable oil gland in the *Apteryges*. He says: "It is a really enormous gland which lies quite normally above the extremity of the vertebral column, though it appears also to extend down the sides of the caudal vertebra." He describes it, and it is figured plate xv.

When at Lake Wakatipu, I heard a good deal about a collector, Mr W. Webb, who at that time was living at a very remote place on the West Coast, Martin's Bay. I was fortunate in meeting Mr Webb, who was on a visit to Queenstown, Wakatipu, on 6th March 1889. He told me that the Kiwis were getting scarcer and were confined to certain localities many miles separated. These birds, he said, seemed to prefer wild rocky places with plenty of boulders among the dense bush. He expressed the opinion that they would become extinct before many years were over. This may have been brought about, although I hope not.

It must be remembered that other agencies besides man are operating against these wingless birds. The introduction of cats, stoats, and weasels has altered conditions, and the birds are no longer safe in their seclusion in the bush. In remote parts of the South Island, far from any dwelling, in 1889, I saw many cats that had become quite wild and had to depend for food upon what they could kill. Stoats and weasels were not in evidence, but they were there all the same.

I spoke to Mr Dall and Mr Webb upon this question, and they were both of the opinion that the animals I have mentioned were very destructive and were having a serious effect in diminishing the number of wingless birds, especially the smaller species. The bush was no protection against such enemies, and from observation they knew that these preying animals were gradually spreading westwards into places that man had seldom, if ever, reached.

For further information regarding the Kiwis and the literature upon them, I would refer the reader to Buller's *Birds of New Zealand*, Professor

A. Newton's and Dr Hans Gadow's *Dictionary of Birds*, and, perhaps most important of all, the paper upon "The Genus *Apteryx*," by the Hon. Walter Rothschild, Ph.D., with a chapter on the anatomy of the Kiwis, by Frank Beddard, Esq., with plates ix. to xvi., in *Novitates Zoologicae*, vol. vi., December 1899.

REMAINS OF *APTERYX HAASTI* IN THE FOLLOWING MUSEUMS, IN WHICH IT IS UNDERSTOOD THE PRINCIPAL COLLECTIONS IN BRITAIN EXIST AT THE DATES MENTIONED.

British Museum, Natural History, Cromwell Road, London, S.W.—

14th March 1913.

3 Skins (2, those of males, and the other, sex unknown) all adults.

Zoological Museum, Tring, Herts, England, belonging to the Hon. Walter Rothschild, Ph.D.—14th March 1913.

20 Skins.

3 Eggs.

University Museum of Zoology, Cambridge.—18th March 1913.

3 Skins of adults (1 female, and 2, sex unknown).

The Free Public Museums, Liverpool.—14th March 1913.

6 Skins.

Royal Scottish Museum, Edinburgh.—24th March 1913.

5 Skins, as follows: 1 Skin, adult ♂
1 Skin, do. ♂
1 Skin, do. ♀
1 Skin, do. ♀
1 Skin of Chick (sex unknown).

5 Skeletons: 1 Perfect ♂
1 Perfect ♀
1 Imperfect ♂
1 Imperfect ♀
1 Imperfect Chick.
1 Egg.
1 Nest.

The Royal Scottish Museum, Edinburgh, appears to be the only one of the museums mentioned to possess either a skeleton or a nest of *Apteryx haasti*. The only eggs of this bird mentioned are 3 at Tring and 1 at Edinburgh.

LIST OF KIWIS AND A FEW OTHER NEW ZEALAND BIRDS PRESENTED TO THE ROYAL SCOTTISH MUSEUM, EDINBURGH.—24TH MARCH 1913.

5 Skins *Apteryx haastii* from Western Ranges, South (or Middle) Island, New Zealand, as follows :—

- 1 Skin, adult ♀
- 1 Skin, do. ♀
- 1 Skin, do. ♂
- 1 Skin, do. ♂
- 1 Skin Chick (sex unknown).

5 Skeletons *Apteryx haastii* :—

- 1 Perfect ♂
- 1 Imperfect ♂
- 1 Perfect ♀
- 1 Imperfect ♀
- 1 do. Chick (sex unknown).
- 1 Egg *Apteryx haastii*.
- 1 Nest do. do.

2 Skins *Apteryx australis* from South (or Middle) Island, New Zealand :—

- 1 Skin, adult ♂
- 1 Skin, do. ♀

1 Skin *Apteryx oweni* from South (or Middle) Island, New Zealand :—

- Adult (sex unknown).
- 1 Egg *Apteryx oweni*.

1 Skin *Apteryx mantelli* from North Island, New Zealand :—

- Very young Chick (sex unknown).

Ocydromus australis.—WEKA :—

- 1 Skin, adult ♂
- 1 Skin, do. ♀
- 1 Skin, do. (sex unknown).
- 1 Clutch of 3 Eggs.
- 1 Nest.

Strigops habroptilus, KAKAPO.—GROUND PARROT :—

- 1 Skin, adult (sex unknown), large adult.
- 1 Skin, do. do. do.

Spiloglaux novæ-zealandiæ, Moorpark.—OWL :—

- 1 Skin, adult (sex unknown).

Prosthematodera novæ-zealandiæ, Tui.—PARSON BIRD :—

- 1 Skin, adult ♂

SCHEDULE OF MEASUREMENTS OF SKINS, SKELETONS AND EGGS OF SPECIES OF *APTERYX*.

SPECIES.	BODY			HEAD			LEGS			FEET	
	From point of bill to end of middle toe.	From point of bill to end of trunk.	From gape to tip of culmen.	Along culmen to point.	From bifurcation to tip of under mandible.	From back of skull to point of bill.	Breadth	Right metatarsus with skin.	Left metatarsus with skin.	Right middle toe with claw.	Left middle toe with claw.
<i>A. haastii</i> , male No. 1	mm. 837	mm. 609	mm. 137	mm. 108	mm. 95	mm. 180	mm. 43	mm. 87 (Leg bones)	mm. 87	mm. 23	mm. 25
<i>A. haastii</i> , male No. 2	806	520	119	90	83	172	38	86	86	24	24
<i>A. haastii</i> , female No. 1	991	710	168	137	110	225	45	90	92	27	27
<i>A. haastii</i> , female No. 2	900	672	157	129	108	212	45	95	95	28	28
<i>A. haastii</i> , chick few weeks old, sex unknown	597	407	67	From gape to tip of culmen 89 mm.	59	136	31	61	60	16	16
<i>A. australis</i> , male	831	350	82	63	49	115	34	62 (Egg: length 113 mm., breadth 70 mm.)	62	17	18
<i>A. australis</i> , female	918	533	149	116	Under mandible 138 mm.	198	41	82	82	23	23
<i>A. mantelli</i> , chick	420	596	157	129	113	228	53	95	96	28	27
very young		305	65	45	38	89	27	43	43	7	7

MEASUREMENTS OF SKELETONS OF *APTERYX* *HAASTII*.

SPECIES.	HEAD				LEGS							
	From back of skull to tip of bill.	Broadest part of skull.	Length of bill from edge of cranial sheath to tip of culmen.	Lower mandible from bifurcation to tip.	Right tibia.	Left tibia.	Right fibula.	Left fibula.	Right metatarsus.	Left metatarsus.	Right femur.	Left femur.
<i>A. haastii</i> , male complete	mm. 162	mm. 39	mm. 100	mm. 81	mm. 148	mm. 148	mm. 106	mm. 105	mm. 86	mm. 85	mm. 100	mm. 102
<i>A. haastii</i> , female complete	189	47	123	105	163	161	112	111	91	87	116	115
<i>A. haastii</i> , male portion	...	...	...	...	...	...	...	...	...	...	112	111
<i>A. haastii</i> , female portion	...	...	...	...	...	...	...	...	...	...	115	115
<i>A. haastii</i> , part chick	...	...	...	...	...	...	...	...	...	...	76	75

Exce measurements : length 124 mm. breadth 80 mm.

Egg measurements: length 124 mm., breadth 80 mm.

XIII.—**Professor Henri Bergson's Biology.** Address delivered on October 28th, 1912, by the retiring President, Prof. J. Arthur Thomson, M.A.

To some it may seem strange indeed that this opportunity for scientific discourse should be used to direct attention to the biological views of a Professor of Philosophy. Is Saul also among the prophets? Can even a brilliant philosopher instruct us in Biology?

Why are we so quick to bid the shoemaker stick to his last? Is it because we know the difficulty of getting a firm grip of any one subject? Or is our jealousy for the sanctity of "intellectual preserves" in part due to the fact that intruders, when really men of might, are more or less upsetting, disarranging our mental furniture and making us uncomfortable?

Whatever may be the motive of our trespass notice-boards, we have only to look around to be convinced that they are of little avail. For the strong day of "intellectual preserves" is over. The philosopher taking Biology seriously has now a welcome as well as a reward; the biologist who disciplines himself in the sublime logic of metaphysics, profits by the philosophers' criticism of his categories. It spells progress that we have biologists like Lloyd Morgan and Driesch in the ranks of the philosophers, and metaphysicians like Bergson and Pringle-Pattison moving with a firm step among the biologists.

Perhaps it is a little unfair to speak of M. Bergson's "Biology," for he makes no profession of giving any systematic treatment of biological problems. He uses biological data primarily for philosophical purposes, on general grounds, since philosophy must take account of all the data that all the sciences lay at her feet, and on special grounds, since he believes that theory of knowledge and theory of life are inseparable, and should push each other on unceasingly. He uses biological data for a second purpose, that he may throw a philosophical light on them. For while he does not of course meddle with biological facts, with which he is much more conversant than some of his critics, he presses home the question whether Biology is altogether right in its choice of the frames in which it encloses these. Bergson tries biological facts in new frames.

It is often interesting to have a favourite passage depolarised by being translated into a new language—one of Burns's poems in German, or one of Heine's poems in Scots. It is interesting to see a familiar landscape in an unusual light—such as that of dawn. So it may be interesting to look at some familiar facts of Biology through Bergson's philosophical eyes.

There is no use pretending that we can skim off the biological cream from M. Bergson's works, or give as it were a bowdlerised version of *L'Evolution Creatrice* with all the philosophy left out. It is not possible to pass even the necessary illustrative quotations through a vacuum chamber to get rid of the philosophical atmosphere with which they are interpenetrated. All that we can do, with doubts if it is quite fair, is to try to focus attention on the biological part of Bergson's picture, leaving out of account, as far as one can, the background metaphysics. And just as one may disagree considerably with Herbert Spencer's philosophy, and yet be grateful for the way in which he vertebrated Biology, so we may disagree considerably with Henri Bergson's philosophy and yet admire his vivid apprehension and statement of biological facts.

Let us ask then how Bergson regards the living organism in its everyday activity, the fact of variability, the general ascent of life, the relation between instinct and intelligence, the factors in evolution, and the urge or impetus of evolution.

THE LIVING ORGANISM IN ITS EVERYDAY ACTIVITY.

The living organism in its everyday life—what are the essential facts about it,—the bee at the flower, the snail on the thorn, the eagle in the air? We try to get at its secret from below, but it eludes our grasp. Chemistry and physics do not and cannot give us more than an analysis of the chemico-physical changes that go on. They show us how to feed and drug the organism, but not how to understand it. Bergson would illumine it by light from above.

What we recognise in the heart of our own conscious life is ceaseless change and yet stable persistence, continual incorporation of the lessons of experience and yet a shooting on to something new. "Our duration is the continuous progress of the past which gnaws into the future and which swells as it advances." "What is our character, if not the condensation of the history that we have lived from our birth—nay, even before our birth?" On the other hand, our life is always something new, something unforeseeable. No one, not even the artist, can foresee the picture. "Even so with regard to the moments of our life, of which we are the artisans,"—perhaps the artists—"each of them is a kind of creation." Now should not something the same be said about the everyday activity of an organism? Is it not also at once an historic and a creative life?

This is Bergson's view, and is it not quite sound biology, for it is agreed by all that the active organism is in ceaseless, constant metabolism, always burning away and yet not consumed—at least not for a day or for many

a day? Or it is like a whirlpool in the river, always changing, yet always the same. And it shows what Huxley called "cyclical development," always re-creating itself. Does development ever stop, even when it turns upon itself in old age? Whether we study the rudiments of behaviour in an Infusorian or the formation of habit in a dog, we see that the organism trades with time.

Whether organisms began as insurgent fragments segregating themselves off from a primeval mass of colloidal carbonaceous slime (activated by ferments), or very much otherwise, as is also possible, must it not have been one of their fundamental insignia that they could somehow enregister within themselves their experience? Bergson's view, at any rate, is that with conscious living beings there emerged "a force essentially free and essentially memory, a force whose very character is to pile up the past on the past, like a rolling snowball, and at every instant of duration to organise with this past something new which is a real creation."

In a popular sort of way we may speak of a stone having a history, and with genial imagination the geologist often treats it very effectively *as if it were* an organism. Of a truth, one often feels that stones, like opals and beryls and agates, are guardians of unreadable experiences. Yet on the whole, it seems clear that a stone does *not* trade with time, as every organism does. The stone that falls ever back on toiling Sisyphus *learns* nothing through the dread eternity. Time does not bite into a *thing*, but only into flesh and blood. Its bite is most marked in higher organisms where there is a good deal to bite at. "The more duration marks the living being with its imprint, the more obviously the organism differs from a mere mechanism, over which duration glides without penetrating."

Bergson, like every good vitalist, is of course quite clear that the organism is bound up with the rest of extension, and "subject to the same physical and chemical laws that govern any and every portion of matter." But the organism transcends this order of interpretation, it is "a closed-off system," heterogeneous and yet one, more or less of an *individual* that *endures*. "Its past, in its entirety, is prolonged into its present, and abides there, actual and acting. . . . *Wherever anything lives, there is, open somewhere, a register in which time is being inscribed.*" Time counts. In the mechanistic outlook "Time is assumed to have just as much reality for a living being as for an hour-glass, in which the top part empties while the lower fills, and all goes where it was before when you turn the glass upside down." But the development of an organism implies a continual recording of experience, a persistence of the past in the present. "The present moment of a living body does not find its explanation in the moment immediately before; *all* the

past of the organism must be added to that moment, its heredity—in fact, the whole of a very long history.” Now this is not to be brushed aside as *a priori* philosophising, it is absolutely in line with such a critical piece of work as Jennings’ study of behaviour in a starfish. In studying this behaviour Jennings proves that we have to take account of past stimuli and past activities. “The precise way each part shall act under the influence of the stimulus must be determined by the past history of that part; by the stimuli that have acted upon it, by the reactions which it has given, by the results which these actions have produced (as well as by the present relations of this part to other parts, and by the immediate effects of its present action). In other words, this complex, harmonious working of the parts together is only intelligible on the view that there is a history behind it; that it is the result of development. We cannot look upon it as a final thing (“etwas Letztes, Naturgegebenes”), because there *is* a history behind it, and we know as solidly as we know anything in physiology that the history of the organism does modify it and its actions—in ways not yet thoroughly understood, doubtless, yet none the less real. The starfish that we have before us has an actual history of untold ages, in which it has existed as germ-plasm or otherwise, and there can be no greater mistake in physiology than to leave this out of account.” This from a biologist is a very interesting corroboration of Bergson’s conception of the organism as *a historic being*. Bergson’s view is this: “The world the mathematician deals with is a world that dies and is reborn at every instant,” but the development of a living creature implies “a real persistence of the past in the present.” Continuity of change, preservation of the past in the present, real duration—the living being seems, then, to share these attributes with consciousness. Can we go further and say that life, like conscious activity, is invention, is unceasing creation?

THE FACT OF VARIABILITY.

The creativeness of life is evidenced in evolution—recapitulated every day, in some measure at least, in development. There has been a continuous *progress* of living creatures, the continuity being sustained by the chain of germ-cells. “Life is like a current passing from germ to germ through the medium of a developed organism.” “Organic evolution resembles the development of a consciousness, in which the past presses against the present and causes the upspringing of a new form of consciousness, incommensurable with its antecedents.” What we call, in Biology, variations—organic new departures—are just the larger steps in a continuous originality and unforeseeability of self-expression. Evolution is a continuous creation of unforeseeable form.

Perhaps it is not going too far to say that this view of the larger variations or mutations, as experiments in organismal self-expression, is one which many a biologist will accept. Is it very different from Galton's conception of the germ getting into a new position of organic equilibrium? Is it very different from Weismann's conception of the hereditary biophors passing through struggle into harmony, constituting themselves a new unity at the start of each life? We have got away—much farther away than Bergson thinks—from the idea of variations as random freaks cropping up in all directions anyhow. There's a method in the changes of Proteus even when he seems most mad.

THE GENERAL ASCENT OF LIFE.

With bold strokes Bergson sketches the significant steps in the ascent of life. How vividly he makes us see the primeval parting of the ways, the first and ever-recurrent choice, the fundamental dichotomy of variation—between swimming and drifting, between activity and passivity, between thrust and parry, between relatively preponderant katabolism and relatively preponderant anabolism. Let us image the primitive Protist—a corpuscle of protoplasm that can experience. "Two courses are open to it. Either it may follow the path leading towards movement, action—action growing more and more complex, more and more deliberate and free as time goes on: this means adventure and risk, but means also a consciousness more and more wide awake and luminous. Or, on the contrary, giving up the faculty of movement and choice that it possesses, even though of course in a very feeble degree, it may decide to fix itself just where it finds suitable conditions of life which will do away with the necessity of going to seek the materials it requires: that means an assured and tranquil life, a humdrum sort of existence, but it involves the drowsiness which dogs our inactivity, it involves the slumber of consciousness."

The first line is in the main that of animal evolution, the second in the main that of plant evolution,—*in the main* since some animals sink into vegetative torpor, and some plants have begun to stretch themselves half-awakening.

"In proportion as plants and animals differentiated, life split up into two kingdoms, of which one, the less concerned with movement, was more concerned with making the explosive, whilst the other confined itself to making use of it." The plant, being able to feed at a low chemical level does not need to retain much movement or feeling. Of course we must not exaggerate the contrast. For just as some animals are only half awake, so some plants are not quite soundly asleep. They have their movements and an exquisite sensitiveness. The impressionability of chlorophyll is

like nervosity in animals. It is interesting to recall the close resemblance between plants and zoophytes. They have a very similar kind of beauty—expressing the dream-smiles of their sleep-like life.

Unembarrassed by a too great multitude of facts, Bergson sees the broad lines of evolution. "In its evolution movement, life is like a shell which suddenly bursts into fragments, which fragments, being themselves shells, burst in their turn into fragments destined to burst again, and so on for a time incommensurably long." He points out that life had to begin humbly. The resistance, the inertia, the stick-in-the-mud-ness of not-living matter had to be overcome. Stooping to conquer, life entered into the habits of the inert. But it had a tremendous internal push, and when it began to get a certain amount of way on it showed its freedom. Changing the metaphor, we see life developing like a sheaf, like a fleur-de-lis, tentatively in different directions. Like a very young child it tried many experiments and got many bumps. The paths show sinuosities, blind-alleys, turnings back, as well as difficulties surmounted. They are neither accidental nor the coercive results of environment. Nor can we fit on the frame of finalism, for nature is more and better than the realisation of a plan given beforehand. Evolution is "a creation that goes on for ever in virtue of an initial movement."

With clear insight Bergson sees that the dichotomy which split Organisations into plants and animals has often recurred. It divides animals into what Prof. Arthur Willey calls Eleutherozoa and Statozoa—the free and the fixed. We see the alternative, ever recurrent, in the contrast between active Infusorians and passive Sporozoa, between feverish birds and sluggish reptiles. Perhaps, as the authors of *The Evolution of Sex* long ago contended, it is the same dichotomy that separates male from female, and masculine from feminine characters.

With clear insight, again, Bergson recognises the extraordinary interest that attaches to the early worms—almost the first creatures to have bilateral symmetry and the first to have head-brains, beginning the long process which has enabled us to tell our right hand from our left. He gives them their due those early worms,—“infinitely plastic forms, pregnant with an unlimited future, the common stock of Echinoderms, Molluscs, Arthropods, and Vertebrates.”

These four great phyla represent the four main directions of the animal kingdom above the “worm” level, but only two have become highways, viz. the Arthropods and the Vertebrates.

Perhaps it was the imprisonment in armour that heavily handicapped the Echinoderms and Molluscs, as Lucretius suggests in his fine phrase “hampered all in their own death-bringing shackles.” At any rate the

Echinoderms and Molluscs yield the road to the Arthropods and Vertebrates just as armour-clad knights had to give place to free-moving infantry men. Suppleness means success.

When we look broadly at Arthropods and Vertebrates which have achieved similar successes on entirely different lines, we see that one thing they have in common is the high development of the sensori-motor system. That is the essential prize, all the rest is trimmings. Plants having gone predominantly into the business of making explosives and having made an inimitable success of it, it was the problem of animals to utilise these explosives effectively. And this is the business of the sensori-motor system. On it everything converges, the other functions are quite subsidiary. When "nervous activity emerged from the protoplasmic mass in which it was almost drowned, it had to summon around itself activities of all kinds for its support," but they are the slaves, it is the master. Hence the index of evolution is in brains.

Looking at the whole set of facts from a still greater distance, we see that the trend of animal evolution is towards freedom. The physical world has only determinate reactions, it is a realm of fatality, in which we always know where we are. The expected happens monotonously. But in the animate world there are alternatives and unforeseeabilities. We see spontaneity even when an Amoeba goes on the hunt, as it certainly does. "At the root of life," Bergson says, "there is an effort to engraft on to the necessity of physical forces the largest possible amount of indetermination." And this it is that gives the nervous system its paramount interest that it is "a veritable reservoir of indetermination." The main energy of the vital impetus has been spent in creating apparatus of this sort.

THE RELATION BETWEEN INSTINCT AND INTELLIGENCE.

Referring to the two great highways of animal evolution—Arthropod and Vertebrate—Bergson points out that two powers, immanent in life and originally intermingled, had here to part company. These are instinct and intelligence, the former finding highest expression in the ants and bees, the latter in man. Bergson's view is that instinct and intelligence are on quite different tacks of evolution, and his theory of knowledge is closely bound up with this part of his theory of life. The problem of instinct is one of the major problems of biology, and many years of experiments like Lloyd Morgan's will be necessary before we can decide between the various views recently discussed before the British Psychological Society. Bergson's interpretation is one of several, and it must suffice to say that it has some of the quality which William James called "tough." This is plain when we

notice that it is precisely comparable to the useful contrast between the little-brain and the big-brain type, expounded many years ago by Sir Ray Lankester, who now writes a preface to a book on Prof. Bergson's "illusions." Sir Ray Lankester pointed out that the minute brain of the ant, rich in ready-made inborn capacities, but far from docile, is on quite a different evolutionary track from the big brain of the dog, poor in instincts, but quick to learn,—eminently educable. Well, this is just Bergson's view.

One of the fundamental sentences in *L'Evolution Creatrice* is this: "The cardinal error which, from Aristotle onwards, has vitiated most of the philosophies of nature, is to see in vegetative, instinctive, and rational life, three successive degrees of the evolution of one and the same tendency, whereas they are three divergent directions of an activity that has split up as it evolved. The difference between them is not a difference of intensity, nor, more generally, of degree, but of kind." To this thesis he has, of course, immediately to add that intelligence and instinct are rarely to be caught pure, for instinct is often accompanied by gleams of intelligence (seen, for instance, when hive bees nest in the open air), and there is no intelligence in which some traces of instinct are not to be discovered.

Intelligence uses unorganised instruments—tools; instinct uses inborn organised instruments. The innate knowledge in instinct is of *things*, of particular pieces of matter; the innate knowledge in intelligence is of *relations*, of forms. Instinct implies intimate and full awareness of a particular configuration of things; intelligence makes frames applicable to many things. If instinct has signs or words, they are *adherent*, "invariably attached to a certain object or a certain operation." Intelligence has mobile signs, which can pass from things to ideas, and thus language has been a great liberator. In short, instinct and intelligence are quite different expressions of life.

The much-debated question of whether instinct is conscious or not, does not trouble Bergson. He holds that there may be lively consciousness in some cases, and that it may be nullified in others. Consciousness is the light that plays around the zone of possible actions, in the interval between representation and action; it is associated with hesitation and choice. Therefore since there is much choice in intelligent behaviour, and little in instinctive behaviour, the latter tends to be less conscious than the former. In many cases it is difficult to say where the organising work of development stops and instinctive activity begins.

THE FACTORS IN EVOLUTION.

In regard to the factors in evolution, Bergson's position is wisely eclectic. Each of the surviving evolution theories is true in its way, corresponding to a

certain aspect of evolution. Thus Darwinism is sound in its recognition of a continual crop of germinal variations which Nature sifts, but its designation of these variations as accidental must be modified.

The idea of definite variations continuing cumulatively in one direction generation after generation—the theory of orthogenesis, in fact—is also accepted as applicable to certain cases. But it is apt to be exaggerated into a denial of spontaneity.

The Lamarckian view that the effort of the organism counts for much in evolution has a big truth in it, but the transmission of the results of changes of function is certainly not the rule, and the effort that really tells is not individual, but, so to speak, racial and germinal.

“A hereditary change in a definite direction, which continues to accumulate and add to itself so as to build up a more and more complex organism, must certainly be related to some sort of effort, but to an effort of far greater depth than the individual effort, far more independent of circumstances, an effort common to most representatives of the same species, inherent in the germs they bear rather than in their substance alone, an effort thereby assured of being passed on to their descendants.” This expresses one of Bergson's fundamental ideas,—the conception of an original vital impetus, sustained right along different lines, the fundamental cause of variations.

In regard to the much-debated question of the possible transmission of individual modifications, *i.e.* bodily changes directly induced by changes in function or in environment, Bergson makes an ingenious suggestion. One of the few known cases worth considering on the affirmative side is that of Brown-Séquard's guinea-pigs in which he quite artificially induced a sort of epilepsy, with the result that some of the offspring were specifically affected. Bergson suggests that the morbid condition may have produced specific cytotoxins which affected the germ-cells specifically. Might not the same be true of some acquired characters? May not the modification—a deep one of course—liberate a specific substance which affects the germ-cells, and in development affects the primordium of the structure corresponding to that which was modified in the parent?

Bergson gives great prominence to a familiar but inadequately studied fact, technically called convergence,—a structural resemblance in organisms belonging to unrelated groups. The two structures that resemble one another in these widely separated types must have evolved independently,—and that is the puzzle. The matter has been recently discussed in a very interesting book by Prof. Arthur Willey.

Why is it that Bergson is so much interested in convergence? Why

does he discuss in great detail the resemblance between the Mollusc eye and the Vertebrate eye? His point is this, that we would be justified in ruling purely mechanistic theory out of court "if it could be proved that life may manufacture the like apparatus, by unlike means, on divergent lines of evolution, and the strength of the proof would be proportional both to the divergency between the lines of evolution thus chosen, and to the complexity of the similar structures found in them." Therefore he takes one interpretation after another of the resemblance between the Mollusc eye and the Vertebrate eye, and finds them wanting. He gives Darwinism and Lamarckism and other isms their innings, but his bowling is very deadly. "How can accidental causes, occurring in accidental order, be supposed to have repeatedly come to the same result, the causes being infinitely numerous and the effect infinitely complicated?" Two eyes—a Mollusc's and a Vertebrate's—with striking resemblances, how are they so much alike, while their histories have been so different? how can any conventional biological theory interpret this production of a similar effect by two different accumulations of an enormous number of small causes? His own answer is that the puzzling sameness is due to the fact that life is the continuation of one and the same impetus divided into divergent lines of evolution. There is "a universal vital impulsion," and it is this fundamental kinship that accounts for convergent organs in widely separated forms of life. It need hardly be pointed out that to show that previous explanations of the puzzle are wrong does not prove that Bergson's explanation is right.

THE URGE OR IMPETUS OF EVOLUTION.

Evolution is racial transformation, and it does not always spell progress. It has its minuses as well as pluses, its parasites as well as pioneers, its hells as well as heavens. The tapeworm is as well adapted to its inglorious lot as the lark to heaven's gate. But admitting all this, we stand face to face with the grand spectacle of the long ascent of life. Throughout the ages life has been slowly creeping upwards. And the question Why? has often been asked. More and more perfect adaptation we can understand, more and more thorough exploitation of the earth, the occupation of every niche, but why this insurgence, this climbing of precipitous heights? Why the big lifts in evolution? Why are we not all Mollusca?

To this question, M. Bergson addresses himself. "Why has life gone on complicating itself, and, moreover, complicating itself more and more delicately and dangerously"—"Why, if there is not behind life an impulse, an immense impulse to climb higher and higher, to run greater

and greater risks in order to arrive at greater and greater efficiency?" "I think it is hard to survey the whole of the evolution of life without the impression that this impulse is a reality."

What is the nature of this vital impulse? "An impulse towards a higher and higher efficiency, something which ever seeks to transcend itself, to extract from itself *more* than there is—in a word, to create." Negatively, it is something that cannot be expressed in the abstractions used in formulating physical events, something that is missed when we use these abstractions in the organic realm. Positively, it partakes of the nature of consciousness.

SCIENCE AND METAPHYSICS.

Let us call a halt and see where we are. When Bergson suggests that a specific hormone liberated from a modified organ may affect the germ-cells and thus influence the offspring in a definite way, he is making an interesting biological hypothesis. When he elaborates his contrast between plants and animals he touches the highwater mark of biological exposition. To give a thrill of fresh interest to that tedious topic is genius. To bring into relief the great steps in evolution and to appraise the merits of the various theories of evolution, that is all within the rubric of science.

When he goes on to show, both directly and indirectly, that the concepts and formulæ that suffice for a description of the inanimate world, and for a practical mastery of it too, do not suffice for the animate world (though they apply of course), then he is dealing, surely, with a question of scientific method.

Furthermore, when he insists that we cannot give an effective account of the behaviour of even a Protozoon, or of the everyday life of either frog or stork, or of the general evolution of organisms, without recognising the rôle of consciousness, not as a phosphorescence on protoplasm, but as a reality that counts, he is still, surely, discussing scientific method. When he goes on to show that the conventional frames used in the intellectual constructions of biology cannot be regarded as quite satisfactory, because they do not harmonise with the rest of our mental furniture, nor with still more solid fixtures, you may call it metaphysics if you like, but it is metaphysics in the modern sense as a methodological science like mathematics or logic—a critical science of explanations.

But when Prof. Bergson goes on to tell us how he conceives of the origin and nature of life, then he plunges us into what is appropriately called "the metaphysics of source"—metaphysics in the ordinary sense.

Bergson's metaphysical theory is that a broad current of consciousness has penetrated matter, carrying matter along to organisation. He does not

keep us in doubt as to what he means by life. Life is consciousness launched into matter—"availing itself of a slight elasticity in matter," "using matter for its own purposes." Consciousness, or rather supra-consciousness, is at the origin of life, and consciousness appears as the motive power in evolution. "Consciousness, or supra-consciousness, is the name for the rocket whose extinguished fragments fall back as matter; consciousness, again, is the name for that which subsists of the rocket itself, passing through the fragments and lighting them up into organisms. But this consciousness, which is a *need of creation*, is made manifest to itself only where creation is possible. It lies dormant when life is condemned to automatism; it awakens as soon as the possibility of choice is restored." In fact an organism is conscious in proportion to its power to move freely—a quaint metaphysical apology for athletics. In the course of evolution it becomes more and more free as the sensori-motor system becomes more perfect. "But, everywhere except in man, consciousness has let itself be caught in the net whose meshes it tried to pass through: it has remained the captive of the mechanisms it has set up." With man, however, a new freedom began. Consciousness is breaking its chains. How free it may become, who shall say?

A SUGGESTION.

At these lofty altitudes the biologist, who is a dweller in tents, loses his breath. Under the sway of his evolution-idea, he finds it difficult to entertain the hypothesis of consciousness being launched into matter as a bolt from the blue. May it not have been that the *anima animans* has been with creation through and through, and from first to last? We think of the majestic order of the heavens and the perfection of the dew-drop, of the extraordinary surge of our whole solar system towards some unknown goal, and of the internal "life" of crystals. We wonder if Time has, after all, simply flowed over the opal and the agate, and whether the beryl has garnered no fruits of experience. Our photograph of a zoophyte—*Sertularia cupressina*—is extraordinarily like the beautiful dendritic frescos which imprisoned Manganese makes on the wall of its cell! To take another example, we admire the intricate zonal structure of Liesegang's rings—formed, for instance, when a big drop of silver nitrate is placed on a film of gelatine in which there is a trace of potassium bichromate. There we see, as the diffusion and precipitation proceed, the rings of growth on a salmon's scale and the zones of the otolith in his ear. There we see, as the diffusion and precipitation continue, the zones of growth in the stem of an oak, in the recesses of a pearl, in the vertebra of a fish, on the scale of a tortoise, and on the barred feather of the hawk. No doubt a wide gulf is

fixed, but the phenomena are extraordinarily similar as well as very different, and our point is simply that too much must not be made of the quality of "inertness" in non-living material.

May it not be that an aspect of reality continuous with the clear consciousness in the higher reaches of life has always been present, though it is negligible for the practical purposes of science until the confines of the inorganic are passed? May it not be allowing us glimpses of its presence in the architecture of the crystal, in the hidden "life" of jewels, and in radio-activity? May it not be expressing itself in the tendency that matter has to complexify—passing from atom to molecule, from simple molecule to complex molecule, and from molecule to colloid masses? May it not lie behind the inorganic evolution which we are beginning to discover? May it not have been resident in the original nebula of our solar system and have in the atom its eternal home?

MECHANISM AND VITALISM.

Who can help wondering that there should be so much oscillation of opinion in regard to the nature of life? The pendulum swings age after age between mechanistic and vitalistic theories, and we seem to make little progress towards the real truth about the living creature. Now it is a machine and again it is a spirit; now it is a free agent and again it is only an automaton; now it is an engine and again we discover that it has an *entelechy*.

There are several reasons for this continual see-saw, the chief one being that there is truth on both sides. For the purposes of chemistry and the physics the organism may be adequately considered as a material system; for the purposes of biology another aspect of its reality has to be recognised.

But another reason is given by Bergson in his theory of the limitation of our intellect. "The intellect, so skilful in dealing with the inert, is awkward the moment it touches the living." "It is characterised by a natural inability to comprehend life." "Created by life, in definite circumstances, to act on definite things, how can it embrace life, of which it is only an emanation or an aspect? Deposited by the evolutionary movement, in the course of its way, how can it be applied to the evolutionary movement itself?" "In vain we force the living into this or that one of our intellectual moulds. All the moulds crack."

THE SECRET OF LIFE.

What then can be done? Some would say, "Nothing! Let us cultivate our garden." Bergson's suggestion is, that our method of pure intellectualism

is wrong. The line of evolution that ends in human intelligence is not the only one. Other forms of consciousness, such as instinct, "express something that is immanent and essential in the evolutionary movement. Have we not powers complementary to the understanding by which we may get a vision—a fleeting vision—of what life essentially is?" We have a fringe of instinct.

Some of the tough-minded, or we ourselves in tough-minded moods, are apt to depreciate that "fringe of vague intuition that surrounds our distinct—that is, intellectual—representation." According to Bergson it is an invaluable organon.

But let no one suppose that this interrogation of instinct—of intuition—is easy. Instinct is like an artist, who will not be questioned. It is nearer to life than intelligence is, but it is not its way to give an account of itself. Thus we are in a dilemma: "There are things that intelligence alone is able to seek, but which, by itself, it will never find. These things instinct alone could find; but it will never seek them." . . . "If instinct could be wound up into knowledge instead of being wound down into action, it would give up to us the most intimate secrets of life." Instinct is more continuous with the force of life than intelligence is. In instinct life fixes its attention on its own movement; in intelligence life fixes its attention on the matter it is passing through.

In sympathy, in artistic and poetic feeling, we come near instinct. We speak of the intuitive insight of the "born doctor" and the divining sympathy of the mother. Bergson says that we do well so to speak. "Instinct is sympathy; if it could extend its object and also reflect upon itself, it would give us the key to vital operations—just as intelligence guides us into matter." "By intuition," he says, "I mean instinct that has become disinterested, self-conscious, capable of reflecting upon its object, and of enlarging it indefinitely." It brings us sympathetically into life's own domain, and makes us feel sure once more that Wordsworth, Emerson, Meredith, and other nature-poets are truest, because deepest, biologists of us all.

XIV.—A List of Anoplura obtained in the Forth Area.

By William Evans, F.R.S.E.

(Read 24th March 1913. Received 29th September 1913.)

LAST year I laid before this Society a list of Mallophaga (Biting Lice) taken in the Forth Area, which has been published in the *Proceedings* (vol. xviii. pp. 265-276). I now submit a list of the Anoplura—the true or sucking lice—that have come under my notice. I rather regret, especially as there are so few of the latter, not having dealt with the two groups in the same paper; but in keeping them apart, I was guided by the widely different systematic positions assigned to them in the “Cambridge Natural History,” the one being there placed along with the Neuroptera, the other with the Hemiptera or bugs. The terms “biting” and “sucking” indicate what has been supposed to represent a fundamental difference between them, but the recent researches of Mr Eric Mjöberg, not to mention the work of others who have touched on the point, do not lend support to this view. His studies, he states,¹ lead him to the conclusion that the Anoplura in their whole organisation present external as well as internal similarities with the Mallophaga, and must have been derived from a common ancestral form. He recognises the moderately near relationship of the Mallophaga to the Psocids, a section of the Neuroptera. The classification of the Anoplura along with the Hemiptera—never more than a doubtful step—would therefore seem to be no longer tenable.

There are doubtless a few other species, besides the thirteen here recorded, to be found in the district were they diligently sought for. *Hæmatopinus* (*Hoplopleura*) *acanthopus* must, one would think, occur on Field and Bank Voles of which we have plenty; yet I have looked for it on a number of occasions without success. In these days of “Economic” Science, the geographical distribution of parasites, as well as their range in the matter of host, is bound to receive more attention than formerly. While the Mallophaga are to be found on mammals as well as birds (their chief hosts), the Anoplura are confined to the former.

Fam. *Hæmatopinidæ*.(= Genus *Hæmatopinus*, Leach.²)

Polyplax spinulosa (Burm.)—In May last I found this species in some numbers on a Brown Rat (*Mus norvegicus* = *decumanus*) at Dalmeny, Linlithgowshire;

¹ Studien über Mallophagen und Anopluren, *Arkiv för Zoologi*, Stockholm; Band 6, No. 13, 1910, p. 262. I had not seen this paper when I drew up my list of Mallophaga.

² The old genus *Hæmatopinus* was split up by Enderlein in 1904 (*Zool. Anzeiger*) into several genera. These Prof. Neumann treats as sub-genera, inserting them in brackets between *Hæmatopinus* and the specific names, thus: *Hæmatopinus* (*Polyplax*) *spinulosus*, Burm., etc.

I had previously looked for it on several occasions without success. Specimens from the same host were exhibited at a meeting of the Edinburgh Naturalists' Field Club by the late James Simpson (*Transactions*, i. 23); no locality is mentioned, but I have no doubt they were got in this neighbourhood. The Rev. James Waterston tells me he obtained it from rats killed at Kirkcaldy in Oct. and Nov. 1909.¹

Polyplax serrata (Burm.)—Specimens of a very small louse taken from mice (*Mus musculus*) in Edinburgh have been kindly given to me by Dr J. H. Ashworth. Presumably they are the *Hæmatopinus serratus* of Burmeister (from the House Mouse), though his description is insufficient to establish this with certainty. Mr Waterston, who has obtained the same species and its eggs on house mice in Shetland, writes me that in 1905 he met with similar small louse eggs on a mouse in Edinburgh. Prof. Neumann, to whom I have submitted specimens, does not recognise the species. A *Hæmatopinus* from a mouse was included in Simpson's exhibit mentioned above.

Polyplax sphærocephala (Burm.)?—In March 1896 I noticed a number of lice on a Squirrel (*Sciurus vulgaris*) captured in a wood near Currie. Unfortunately I did not preserve any of them, but I have little doubt they were this species.

Polyplax ventricosa (Denny)—*Hæmatopinus ventricosus*, Denny, "Monogr. Anopl. Brit."—From Wild Rabbit (*Lepus cuniculus*), Dunipace, Stirlingshire, March 1910, and Tynninghame, East Lothian, April 1910; a good many on each occasion. Enderlein placed this species in his genus *Hæmodipsus*, but Neumann has shown² that it really possesses the characteristics of a *Polyplax*.

Hæmodipsus lyriocephalus (Burm.)—*Hæmatopinus lyriocephalus*, Denny's Monograph.—Several from Brown Hare (*Lepus europæus*), Tynninghame, April 1910.

Linognathus piliferus (Burm.)—*Hæmatopinus piliferus*, Denny's Monograph.—Common on Dogs (*Canis familiaris*): Edinburgh, February 1906; Dirleton, East Lothian, Nov. 1909; etc.

Linognathus ovillus (Neum.)—*Hæmatopinus ovillus*, Neumann, *Revue vétérinaire*, Aug. 1907, pp. 520-524.—From Black-faced Sheep (*Ovis aries*, var.), Crosswood Hill, Pentlands, Midlothian, April 1906, May 1907, and April 1912. Mr W. F. Little, to whom I am indebted for bringing this interesting novelty to my notice (see my paper in *Ann. Scot. Nat. Hist.*, Oct. 1907, p. 225), tells me that every year it occurs in numbers on the faces and cheeks of a few of the sheep on the hill. In April last, however, he obtained some for me from the legs also of one of the sheep, and they are in no way different from those from the face. I mention this, as a totally different species (*H. pedalis*) has been described by Osborn from the legs of sheep in North America. When I first obtained *ovillus* it was undescribed, though Prof. Neumann had shortly before received it from New Zealand. It seems to me to fall into Enderlein's genus *Linognathus*.

Hæmatopinus eurysternus (Nitzsch)—From Cows (*Bos taurus*, ♀), Crosswood, Pentlands, Nov. 1905, and March 1906, and Hunter's Tryst, near Edinburgh, May 1906.

Hæmatopinus suis (Linn.)—From Pigs (*Sus scrofa*), Newbattle, 1904, and Swanston, Midlothian, April 1906; Dunipace, Aug. 1911; Tynninghame, July 1912; etc.

Fam. Pediculidæ.

Pediculus capitis, Leach, and **Pediculus vestimenti**, Leach—On Man, the former chiefly on children. Both forms are still too common. "Verminous cases" are

¹ Mr Waterston has also an undetermined *Polyplax* ♂ from a *Mus sylvaticus* captured at Colinton in 1905.

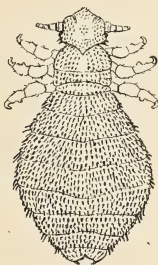
² *Archives de Parasitologie*, 1909, p. 527.

not difficult to find in the city slums, but they are by no means confined to these, as the medical inspection of school children in town and country has shown.

Phthirus inguinalis, Leach—On Man. Though much less frequent than the above, this also, medical men in Edinburgh tell me, is still not so uncommon as one would like to think.

Fam. **Echinophthiriidæ.**

Echinophthirius phocæ (Lucas)—A Common Seal (*Phoca vitulina*) shot on the Isle of May by one of the lighthouse staff (W. Mouat), in Jan. 1913, was terribly infested with this interesting species. On a small piece of its skin (from in front



E. phocæ, ♀, $\times 16$.

of shoulder) which was sent me I found them in hundreds—43 were taken off one square inch—and every hair had one or more eggs attached to it.¹ I am not aware of any published record of *E. phocæ* from the British Isles, but I understand the Rev. James Waterston has recently obtained it in Shetland.² Its thick coating of stiff hairs no doubt serves to retain a supply of air for respiration while its host is under water.

¹ The egg of this species is figured by Mjöberg (*loc. cit.*, p. 259).

² Mr Waterston has since recorded this occurrence in *Ent. Mo. Mag* for May 1913, p. 113.

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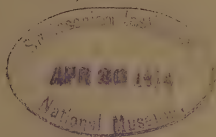
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XV.—Egg Coloration in the Cuckoo, *Cuculus canorus*, and its bearing upon the theory of Cuckoo Sub-species. By John Rennie, D.Sc., F.R.S.E., University of Aberdeen.

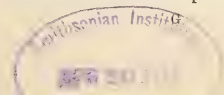
(Read 27th October 1913. MS. received 12th November 1913.)

THROUGH the generosity of Mr R. Hay Fenton, Aberdeen University possesses one of the finest collections of clutches of birds' eggs in the country. This collection includes 300 Cuckoos' eggs together with the foster clutches with which they were found. The value of Mr Fenton's gift is further enhanced by the fact that he has along with it supplied much important data regarding the eggs, and, in particular, has given a full list of localities and dates of their taking.

The material and information thus available have made possible the use of the collection for scientific investigation, and I wish here to express my indebtedness to Mr Fenton for calling my attention to the particular facts submitted and discussed in this paper dealing with egg coloration in *Cuculus canorus* and its bearing upon Newton's theory of Cuckoo "gentes." This theory has recently obtained some support from biometric evidence supplied by Latter (3).

It is well known that *Cuculus canorus* practises the parasitic habit of foisting the duty of incubation and rearing of its offspring upon a large number of different birds. Sharpe puts the number of species at 119. In the Fenton collection we have evidence of about 60 species in Britain.

It is generally held that individual Cuckoos in the main parasitise upon particular species of fosters during the whole of their lives, transmitting this bias to their offspring, and Newton has suggested that by this means several "gentes" of Cuckoos have thereby become established. The main evidence for this suggestion is found in the coloration and size of the egg. Latter investigated the problem biometrically, taking length and breadth dimensions in 1572 eggs, and claims that the balance of evidence is "decidedly in favour of there being distinct sets of Cuckoos." He finds evidence, in particular, of races of Robin-cuckoos, Wren-cuckoos, Whitethroat-cuckoos, and Hedge-sparrow-cuckoos, and says, "It now seems fairly certain that Prof. A. Newton's suggestion is correct, and that there are certain 'gentes' of Cuckoos whose members being closely related lay eggs of somewhat similar dimensions, and in the main confine their attentions, generation after generation, each to its own particular variety of foster parent. In other words, the evidence here adduced points to the conclusion that the species



Cuculus canorus is tending to break up into a number of sub-species, each with its own particular habits in respect of selecting a foster parent" (p. 363).

It is not my intention in the present paper to criticise this conclusion on the evidence submitted in Mr Latter's paper, further than to remark that there appears to be an arithmetical slip in his determination of the significance of the difference between the mean lengths of the total Cuckoo eggs treated of and the mean length for the "Sedge-warbler-cuckoo" group. Besides, the standard deviation of sampling used is not that of the difference between a general mean and a local mean, which is the difference Latter considers. Even when the correct formula is used it does not render distinctly significant the difference in the "Sedge-warbler-cuckoo."

The proposition here submitted, based upon the coloration of the Cuckoo's egg, is that the assumed habit on the part of the Cuckoo of adhering to a particular species of foster bird is not in general agreement with fact. Further, we have here confirmed two generally recognised facts:—

- (1) A considerable variability of colour in Cuckoos' eggs in general;
- (2) A marked uniformity of colour of the egg of the individual bird.

An examination of the 300 Cuckoo eggs in the Fenton collection reveals the fact that in this species there is a wide range of variation as regards egg coloration. This agrees with the observation of other investigators, *e.g.* Newton (4), Baldamus (1), Herrick (2). Herrick states: "When taken at random they are very variable in colour, ranging from blue, or blue-green, through speckled blue, brown, mottled or marbled brown, and grey to nearly plain white." There is also general agreement upon the question of the uniformity in coloration of the eggs of the individual Cuckoo. Newton writes: "It is unquestionable that whatever variation there may be among the eggs laid by different individuals of the same species, there is a strong family likeness between the eggs laid by the same individual, even at the interval of many years" (D. of B., p. 123). Herrick states: "The same Cuckoo always lays eggs of similar colour, colour pattern, size and form in a single season, and probably during life. According to Baldamus this has been proved to hold true in one case for three successive years. If two or three Cuckoos' eggs are found in the same nest, they are supposed to belong to different birds, and no case is known where such eggs were similarly coloured."

An examination of the Cuckoos' eggs in the Fenton Collection, grouped according to locality and date of taking, shows the presence, in numerous instances, of sets of eggs of strikingly uniform coloration. No other

conclusion can be drawn as to their origin, so remarkably similar are the eggs, than that they are the product of the same bird. In most cases the groups of eggs, arranged on the basis of locality and near dates, show distinctly more agreement as regards size and colour than do the foster eggs within the individual clutches. The following are illustrations :—

I.—*Two eggs taken at Budworth Mere, Cheshire.*

Museum No.	Foster.	Date when taken.
A 6/2 . . .	Reed Warbler . . .	29th May 1910
A 6/3 . . .	Reed Warbler . . .	5th June 1910

These eggs are of a bluish-grey colour, with dull brownish blotching; there are abundant fine dots and also numerous larger specks of varying shape and size. The eggs are not noticeably darker in colour at the broad end. The two eggs cannot be distinguished. There is one foster type only.

II.—*Four eggs taken at Budworth, Cheshire.*

Museum No.	Foster.	Date when taken.
G 15/1 . . .	Sedge Warbler . . .	8th June 1910
G 6/8 . . .	Reed Warbler . . .	10th June 1910
G 15/2 . . .	Sedge Warbler . . .	13th June 1910
G 6/9 . . .	Reed Warbler . . .	18th June 1910

These are pale grey eggs with finely grained brown markings. There are numerous sharply defined dark brown spots. The resemblance is most marked in all four eggs. There are two types of foster in this case. Taken in conjunction with the foregoing set two Cuckoos are indicated in this area.

III.—*Set of two eggs, presumably of the same bird, taken near Lancaster.*

Museum No.	Foster.	Date when taken.
D 11/3 . . .	Yellow Bunting . . .	22nd May 1912
D 13/2 . . .	Hedge Sparrow . . .	27th May 1912

This is a greyish egg with a good deal of brownish pigment in fairly large irregular patches well distributed evenly over the whole egg, but more deeply at the broad end. There is a brownish speckling over the whole end area in both eggs—not in the form of a ring. On both eggs there are a very few quite dark brown well-defined marks. The egg in the Yellow Bunting's nest resembles well the eggs of the foster, but is a little darker. That in the nest of the Hedge Sparrow is, of course, conspicuous. There are two foster species.

IV.—*Two eggs, apparently laid by the same bird, taken at Delamere, Cheshire.*

Museum No.	Foster.	Date when taken.
F 15/3	Sedge Warbler	2nd June 1912
F 29/1	Lesser Whitethroat	6th June 1912

These are pale grey eggs with brown spots. The general impression is that of a very uniform lightish coloration, *i.e.* the speckling is very evenly distributed. The two eggs are remarkably alike and cannot be distinguished. There are two kinds of foster in this case also.

V.—*Three eggs, apparently laid by the same bird, taken at Wigglesworth, Yorkshire.*

Museum No.	Foster.	Date when taken.
B 16/2	Willow Wren	23rd May 1910
B 7/2	Meadow Pipit	27th May 1910
B 18/2	Spotted Flycatcher	28th May 1910

These show a most marked resemblance to each other. Colour is greyish-blue with brown speckling evenly distributed. There are a few darker spots of brown, very small but sharply defined. The three eggs cannot be distinguished save by these spots, which are of course not identical in size or numbers. It is noteworthy, notwithstanding the probability of their being the product of the same bird, that each occurred in the nest of a separate species of foster. The collector states that "all of the three eggs were found close to where water was in abundance, both stagnant pools and running."

VI.—*Six eggs, taken by the banks of the River Ouse, in Huntingdonshire, within a range of half a mile.*

Museum Mark.	Foster.	Date when taken.
C 11	Sedge Warbler	11th June 1909
C 1	Sedge Warbler	16th June 1909
C c	Reed Warbler	17th June 1909
C x	Lesser Whitethroat	18th June 1909
C w	Whitethroat	18th June 1909
C h	Hedge Sparrow	14th July 1909

The ground hue of these eggs is of a bluish-grey, with brown speckling fairly thickly distributed. The colour contrasts quite noticeably with that of the next set, which was taken in the same region but over a wider area, and all, with one exception, in the following year. With the exception

that in egg Cx there is a suggestion of a dark band at the broad end, it is impossible by ordinary observation to distinguish these eggs from each other. The nests of five foster species are represented by these six eggs.

VII.—*Eleven eggs, believed to be laid by the same bird, taken by the River Ouse, Huntingdonshire.*

Museum Mark.	Foster.	Date when taken.
E v	Reed Warbler	18th June 1909
E c	Reed Bunting	24th May 1910
E 11	Sedge Warbler	4th June 1910
E °	Whitethroat	4th June 1910
E 5-1	Sedge Warbler	6th June 1910
E w	Whitethroat	8th June 1910
E/o	Sedge Warbler	8th June 1910
E v ¹	Sedge Warbler	8th June 1910
E iii	Reed Bunting	11th June 1910
E x	Reed Warbler	11th June 1910
E o/	Reed Warbler	15th June 1910

Notes on the individual Eggs of this Group.

E v. This egg resembles the Reed Warbler's in appearance, but is lighter, the speckling is more uniform in size all over, not run into blotches but more thickly laid down at the broad end, forming an irregular ring not unlike a Blackbird's egg.

E c. The above description holds good for this egg.

E 11. This egg cannot be distinguished from the foregoing.

E °. On this egg are two end-spots sharply defined; otherwise as above.

E 5-1. Quite similar to the others already mentioned. The markings are not so intense as those of the Sedge Warbler in this nest, nor so greenish, but except for size the egg is remarkably like the foster eggs.

E w. A marked general resemblance to others of this set.

E/o. Like the rest. The resemblance here to the foster eggs is remarkable. The Sedge Warbler's eggs here are darker than those of *E 11*; they vary more amongst themselves than do the Cuckoos' in this set.

E v¹. This egg is slightly paler than the others on one side, towards the narrow end.

E iii. Like the others generally.

E x. There are some larger spots towards the narrow end, but general appearance is as the others.

E o/. Like the others generally.

An unbiased examination of these eggs and their foster clutches suggests the following observations:—

(a) There is a resemblance in coloration both as regards intensity and distribution which is remarkable.

(b) It is not surpassed nor even equalled in the coloration of the eggs composing the individual clutches in which the eggs have been found. There is noticeable variation in the different clutches of the same kind of bird's eggs, *e.g.* Sedge Warbler's in this collection which contrasts with the uniformity of appearance of the Cuckoo's eggs of the series.

We have here either the eggs of two or more birds, in which case a marvellous coincidence of colour resemblance extending to eleven eggs occurs; or the eggs are those of a single bird.

If the latter alternative be correct, two facts of interest are to be noted. One is the confirmation of the observations of Baldamus and others that the resemblance in the eggs of the individual Cuckoo extends from one year to another. The second is that a single Cuckoo may lay as many as ten eggs in a season, and that within so short a period as twenty-two days.¹

Further, it will be noted there are four foster species involved; these however all nest in similar situations. The actual distance limit of this Cuckoo's ovipositing operations here considered was about two miles.

VIII.—*Three eggs, taken in Huntingdonshire.*

Museum No.	Foster.	Date when taken.
K 1 . . .	Robin	24th May 1913
K 2 . . .	Yellow Hammer	24th May 1913
K 3 . . .	Sedge Warbler	26th May 1913

These are pale greenish eggs with brown blotching, mostly at the broad end. These eggs were all taken in the same area. Three foster species are involved.

IX.—*Three eggs, taken in Huntingdonshire.*

Museum No.	Foster.	Date when taken.
L 4 . . .	Sedge Warbler	26th May 1913
L 6 . . .	Robin	29th May 1913
L 13 . . .	Reed Warbler	3rd June 1913

¹ Six to seven is the usual number of eggs reputed to be the product of a single Cuckoo in a season. I do not know upon what evidence this is based, but considering the contingencies in the matter of rearing there might well be a compensating factor in this species in the direction of an increased egg production.

These are grey eggs with a moderate amount of brownish speckling. The small brown dots are fairly numerous and quite noticeable upon these eggs. A comparison of the eggs of this set with those in the previous one reveals a difference in ground colour and in size and amount of superimposed blotching. Although the two sets are from the same area, they are probably the product of two different Cuckoos. Again, three foster species are involved.

X.—*Seven eggs, taken in the same district as the two preceding sets.*

Museum No.	Foster.	Date when taken.
H 7 . . .	Reed Warbler . . .	3rd June 1913
H 8 . . .	Lesser Whitethroat . . .	5th June 1913
H 10 . . .	Reed Warbler . . .	12th June 1913
H 11 . . .	Reed Warbler . . .	16th June 1913
H 12 . . .	Sedge Warbler . . .	23rd June 1913
H 14 . . .	Reed Warbler . . .	24th June 1913
H 15 . . .	Whitethroat . . .	29th June 1913

These eggs again differ from the two previous sets, but amongst themselves constitute a very uniform group. The ground colour is a pale bluish-green of a deeper tint than set K. The latter is a yellowish-green; this set, when placed alongside, looks quite different. The grain of brown speckling is finer and does not run into large blotches as in set K. Four foster species are involved.

XI.—*Two eggs, taken at West Clitheroe.*

Museum No.	Foster.	Date when taken.
I 7/12 . . .	Meadow Pipit . . .	19th May 1913
I 4/10 . . .	Tree Pipit . . .	22nd May 1913

This is a pair of beautiful eggs of a general pale reddish hue, with reddish-brown speckling thickly distributed, especially at the broad end. The eggs are quite different in appearance from any of the other sets described in this paper, whilst they are practically indistinguishable from each other. There are two fosters in this case.

XII.—*Three eggs, taken near Huntingdon.*

Museum No.	Foster.	Date when taken.
5 . . .	Hedge Sparrow . . .	28th May 1913
9 . . .	Whitethroat . . .	5th June 1913
16 . . .	Reed Warbler . . .	1st July 1913

This is a specially interesting series. Nos. 5 and 9 are greyish in colour, moderately well speckled with brown. No. 5 is slightly darker than No. 9 at the broad end, but they fit in well as a pair with the general theory of common parentage. No. 16 is an egg of a different type, smaller in size and pale bluish-green with regularly distributed small grained brownish speckling. It is probably the egg of a separate bird. On comparing it with the eggs of series X., from the same area and of same year's taking, and particularly with H 14 and H 15 which were found about the same time (24th and 29th June), we still find this egg distinctive. Whilst it approaches these two more nearly in appearance, its ground colour is of a deeper blue and the amount of brown speckling is rather greater. It is also a smaller egg.

XIII.—*Two eggs, taken at West Drayton (Bank of Colne) Middlesex.*

Museum No.	Foster.	Date when taken.
M 6/14	Reed Warbler	1st July 1912
M 15/5	Sedge Warbler	11th July 1912

These eggs are of a pale, sandy colour, with light brown speckling running in places into fairly large blotches. The brown colouring is moderately sparse, generally, and absent at the narrow end of the egg which is rather pointed looking. The resemblance of the two eggs is rather striking, and they are probably the offspring of the same bird. Two foster species are involved.

When single eggs of the foregoing thirteen series taken at random are placed alongside, the interesting fact becomes evident that with one exception no two resemble each other, even approximately, as the members of the sets themselves do. Further, a comparison of sets from the same locality, by the method of taking an egg at random from each group, yields eggs readily distinguished by their colour in each case. There are two sets from Budworth Mere, Cheshire, of the same season, and these are quite distinct when laid alongside, the difference being more marked than any verbal description can bring out.

There are six sets from Huntingdonshire, representing three different years' takings. Sets IX. and XII. are rather alike, but their resemblances are not so great as the members of any of the sets considered in this paper. They constitute the one exception quoted above. The other examples can all be distinguished at a glance from these and from each other.

What conclusions can be drawn from these facts?

The following are possible explanations:—

(a) The resemblance between the eggs of each of the “sets” is coincidence merely, the eggs of a “set” being the product of two or more birds.

(b) The eggs of each set are the product of a single bird.

Now, should the former view be accepted and the theory of Cuckoo “gentes” be also adhered to, we have the following facts to face. We must hold, generally, that in each of the supposed “sets” there are as many Cuckoos represented as there are foster species. We need not postulate more, although there might be more.

For example:

Set I.	Two eggs	.	.	.	One foster species.
Set II.	Four eggs	.	.	.	Two “
Set III.	Two eggs	.	.	.	Two “
Set IV.	Two eggs	.	.	.	Two “
Set V.	Three eggs	.	.	.	Three “
Set VI.	Six eggs	.	.	.	Five “
Set VII.	Eleven eggs	.	.	.	Four “
Set VIII.	Three eggs	.	.	.	Three “
Set IX.	Three eggs	.	.	.	Three “
Set X.	Seven eggs	.	.	.	Four “
Set XI.	Two eggs	.	.	.	Two “
Set XII.	Three eggs	.	.	.	Three “
Set XIII.	Two eggs	.	.	.	Two “

What is the probability, we may pertinently ask, of *five distinct birds* (Set VI.) in the same district all laying in the same season, each in a *separate foster-species nest*, eggs so resembling each other in ground hue, depth and distribution of superimposed pigment that they cannot be distinguished from each other? Such is not likely to be the case; the probability is very remote.

A similar argument applies to the other sets. Take Set VII. Here also it is highly improbable that four birds will, amongst them, lay ten eggs which in colour cannot be distinguished from each other. And so with the other groups.

Let us consider the other alternative. The eggs of the groups or “sets” discussed in this paper may be regarded as the product of a single bird. To most observers who may examine these eggs, this will probably be the more acceptable alternative. It involves fewer difficulties.

Close resemblances between the offspring of a single bird are more to be expected than between those of several. From such a conclusion it follows:—

Cuckoos laying in Sedge Warblers', Reed Warblers', Whitethroats', Lesser Whitethroats', Reed Buntings', Robins', Hedge Sparrows', and other named birds' nests do not in England form separate gentes, "each with its own particular habits in respect of selecting a foster parent."

It may, of course, be pointed out that it is not held that individuals of a supposed "gens" adhere in every case to the gens type of foster nest, but only "in the main." This means, however, that the departure from the "gens" habit is exceptional, which cannot be claimed with regard to the cases under consideration. In all these the foster species are multiple, except one—(I.) a case of two eggs in Reed Warblers' nests.

An important factor bearing upon the problem of the evolution of Cuckoo "gentes" exhibiting specialised egg characters is the polyandric habit of the Cuckoo. If we allow that the female exhibits a hereditary bias in the selection of foster parents for her offspring which is evolving along with a definite morphological differentiation in egg dimensional characters, we exclude the male parent, *who may be of a different gens*, from exercising any hereditary influence upon the "foster-bias" of the offspring, with its accompanying egg differentiation. To put the matter concretely: if a female bird bred from a "Robin-cuckoo" gens mates successively with a male of "Hedge-sparrow-cuckoo" stock and with a male of, say "Wren-cuckoo" stock (assuming that such stocks exist), will the offspring of these matings be "Robin-cuckoos" only or even mainly? The "gens-theorists" must have an answer to this problem?

For the view of a possible evolution of "gentes" going on, it may be stated: Cuckoos may come back not only to the locality but to the particular hedge or reed bank in which they were reared, in search of a foster parent for their offspring. It is possible that they are predisposed—some more, some less—to observe more readily, and so to find the species and the nest of the type which incubated and reared them. There may be *pari passu* with this, a process of Natural Selection going on whereby an increasing number of Cuckoos reared by foster species of a specially assiduous and faithful type are surviving, and in turn a majority of these, reminiscent of and let us hope grateful for past privileges, which tend to seek a similar foster parent for their own offspring. In some such way physiological sub-species may be in process of forming.

This theory is plausible enough, and there may be some support for it in the frequency with which in some districts a particular type of foster

is common, *e.g.* Meadow Pipit. But it must be admitted that this view is open to criticism similar to that suggested above. As regards the foster species considered in this paper, all that the evidence may safely be claimed to show is that while a bias towards a particular haunt, *e.g.* a river bank, may be exhibited by a Cuckoo, the choice of species for foster parents within that haunt would appear to be determined more by the frequency of occurrence of its nests, or the facility with which the nests are discovered by the Cuckoo, than by any hereditary bias towards a particular foster.

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XVI.—A Contribution to the Spider Fauna of Scotland. By A. Randell Jackson, M.D., D.Sc. (Communicated by Wm. Evans, F.F.A., F.R.S.E.)

(With Plates.)

(Received 11th November 1913. Read 24th November 1913.)

I.—INTRODUCTION AND LOCALITY RECORDS.

THE following paper contains an account of a short holiday in Scotland, which was spent for the most part in collecting spiders. I was only absent from home fifteen days, and was much hampered by wet and stormy weather. Nevertheless, I had considerable success, and believe that this was due chiefly to the carefully planned itinerary. In all thirteen species were added to the Scottish list. Eight of these were new to Britain, and two of these eight I am introducing as new species. The following are the names of these thirteen species:—

<i>Xysticus luctuosus</i> Bl.	<i>Coryphæus mendicus</i> L. Koch.
<i>Entelecara errata</i> Camb.	<i>Erigone tirolensis</i> L. Koch.
<i>Styloctetor morula</i> Camb.	<i>Tiso æstivus</i> L. Koch.
<i>Maro Falconerii</i> Jackson.	<i>Theridion bellicosum</i> E. Sim.
<i>Maso Brittenii</i> Jackson.	<i>Robertus scoticus</i> sp. nov.
<i>Clubiona subsultans</i> Thor.	<i>Leptyphantès cacuminum</i> sp. nov.
<i>Zilla Stroemii</i> Thor.	

Of these the first five are new to Scotland, the next six to Britain, and the last two, I believe, to Science. In all 130 species of *Aranææ*, 6 of *Opiliones*, and 2 of *Pseudo-scorpiones* were obtained. I did not, however, go out of my way to look for common species.

The following places were visited:—Aberlady links and sandhills, a day; Trossachs, about three hours; Rannoch, about four days; Schiehallion, a day; Ben Nevis, rather over two days; Mallaig, a couple of hours; Crinan, a couple of hours.

Of course in such an extended tour a great deal of time was spent in travelling. I must admit, too, that much was consumed in the admiration of scenery. The weather during the whole time I was at Rannoch was terrible.

The chief moral of these results is that the Highlands of Scotland are almost virgin soil as far as *Arachnids* are concerned. Prof. Trail, Mr W. Evans, and the Rev. J. E. Hull have done good work, but far more investigators are wanted. Half-a-dozen collectors in different parts of the Highlands would do wonders. Is it too much to expect that Edinburgh should produce them?

On June 5th, Mr Wm. Evans kindly took me to Aberlady, the locality

for *Dictyna arenicola* Camb.—the type specimens were taken by him there in 1894 (cf. *Proc. Roy. Phys. Soc.*, vol. xii.). We went by train and walked along the links and sandhills to Gullane. With the exception of the *Dictyna* nothing rare was found. This locality has, of course, been well worked by Mr Evans, so novelties were not expected. The following Arachnids were obtained :—

Dictyna arenicola Camb. About five females and a dozen males, all adult. Immature examples numerous. Nearly all the females were in this state. Probably we were a week or two early for the species. The examples were found chiefly in little silken nests spun in bits of dry, blown seaweed or dead thistle leaves. Sweeping the rank herbage produced none. Some of the males were wandering about the sand.

Tiso vagans Bl. Common.

Savignia frontata Bl.

Diplocephalus permixtus Camb.

Lophomma punctatum Bl.

Pocadicnemis pumila Bl.

Entelecara trifrons Camb. One male.

Neriere rubens Bl.

Enidia bituberculata Wid.

Edothorax retusus Westr.

Trachygnatha dentata Wid.

Erigone dentipalpis Wid.

Bathypantes parvulus Westr.

Leptyphantes tenuis Bl.

Clubiona grisea L. Koch. Male and female.

Xysticus cristatus Clerck.

Chelifer Latreillii Leach. Several specimens of this Pseudo-scorpion were found in the crevices of some rocks, in a locality pointed out by Mr Evans.

On June 6th, Mr Evans and myself had three or four hours' collecting in the Trossachs. We hoped to find *Linyphia marginata* C. L. K. there. This species had been obtained in this locality by the Rev. O. Pickard-Cambridge many years ago. In this, however, we were unsuccessful. We obtained a good many species of Arachnids, none of which were very rare, as the following list will show :—

Dictyna arundinacea L.

Clubiona trivialis L. Koch.

„ *compta* C. L. K.

Zora spinimana Bl.
 „ *nemoralis* Bl.
Xysticus cristatus Clerck.
Evarcha falcata Bl.
Lycosa pullata Clerck.
 „ *lugubris* Walck.
Robertus arundinetus Camb. One male.
Ceratinella brevipes Westr.
Tiso vagans Bl.
Diplocephalus fuscipes Bl.
Wideria cucullata C. L. K.
Edothorax agrestis Bl.
Dismodicus bifrons Bl.
Maso Sundevallii Westr.
Microneta viaria Bl.
Porrhomma pallidum Jackson. One male.
Leptyphantes tenebricola Wid.
Labulla thoracica Wid.
Linyphia peltata Wid.
 „ *pusilla* Sund.
Tetragnatha extensa L.
Meta merianæ Scop.
 „ *segmentata* Clerck.
Platybunus corniger Herm.
Phalangium opilio L. Immature examples.
Mitopus morio Fabr.
Obisium muscorum Leach.

I then journeyed to Kinloch Rannoch, on June 7th, and stayed there till the morning of June 13th. Unfortunately the weather was very bad. For the whole time it blew violently, and for the first three days rained almost incessantly. Collecting was very uncomfortable. I was, however, very anxious to explore the Black Wood, and the summit of Schiehallion, and managed to do both successfully. The following Arachnids were obtained:—

June 7th, near Kinloch Rannoch :

Hahnia montana Bl.
Theridion pallens Bl.
Pholcomma gibbum Westr.
Minyriolus pusillus Wid.
Leptyphantes obscurus Bl.
Epeira cornuta Clerck.

June 8th, 10th and 11th. Black Wood of Rannoch.—This seems a very rich locality. In spite of the rain on two of the days I was there, I obtained a large number of species, three of which were new to Britain, and one of these apparently to Science. There is no doubt that patient and careful work here would turn up many new things. The following is a complete list of the Arachnids found:—

Segestria senoculata L.

Clubiona trivialis L. K.

„ *comta* C. L. K.

„ *subsultans* Thor. This species was new to Britain. It was found under the bark of Scots pines. One male and two females occurred. See note on p. 125.

Xysticus cristatus Clerck.

„ *luctuosus* Bl. A single female of this species, which is new to Scotland. Its headquarters seem to be in the south of England.

Philodromus aureolus Clerck.

„ *cespiticollis* Walck.

„ *emarginatus* Schranck. One female, beaten from a pine tree.

Salticus cingulatus Panz.

Neon reticulatus Bl.

Cryphœa silvicola C. L. K. This was very abundant under the bark of pines.

Hahnia helveola Sim.

„ *montana* Bl.

Pirata hygrophila Thor.

Trochosa terricola Thor.

Lycosa pullata Clerck.

Dolomedes fimbriatus Walck. Several immature individuals. I have given these the name of the only species so far known to inhabit Britain, but they might easily turn out to be of another allied species; this can only be settled by getting adults.

Dictyna arundinacea L.

Ciniflo fenestralis Stroem.

Theridion sisypium Clerck.

„ *pallens* Bl.

„ *varians* Hahn.

Robertus scoticus sp. nov. A single female of this form, which was apparently undescribed, was found amongst moss. See note on page 120.

- Theonoe minutissima* Camb. One female, amongst moss.
Ceratinella brevis Westr.
Diplocephalus fuscipes Bl.
 „ *Beckii* Camb. One female.
Lophomma herbigradum Bl.
Pocadicnemis pumila Bl.
Minyriolus pusillus Wid.
Styloctetor penicillatus Westr.
Nerienne rubens Bl.
 „ *rubella* Bl.
Dismodicus bifrons Bl.
Erigone promiscua Camb.
Syedra innotabilis Camb.
Agyneta cauta Camb.
Sintula corniger Bl. One female.
Rhabdoria diluta Camb.
Centromerus arcanus Camb. Females.
Leptyphantes ericæus Bl.
 „ *Mengii* Kulcz.
 „ *obscurus* Bl.
 „ *Zimmermannii* Bertk.
Labulla thoracica Wid.
Linyphia pusilla Sund.
Tetragnatha extensa Linn.
Meta segmentata Clerck.
Cyclosa conica Pall. Females.
Zilla Strömii Thor. New to Britain. A very fine and distinct thing,
 found under and on the bark and trunks of Scots pines. See
 note on page 125.
Epeira cucurbitina Clerck. An adult male, and numerous immature
 specimens.
 „ *umbratica* Clerck.
 „ *Sturmii* Hahn. Both sexes adult.
 „ *quadrata* Clerck.
Megabunus insignis Meade.
Obisium muscorum Leach.

Cocoons of an *Ero* and an *Agroëca* were found, but in the absence of adult spiders it was impossible to be sure of the species.

The shores of Loch Rannoch were worked a little in several places, both

on the north and south sides. Nothing of great rarity was found, the following being the complete list:—

Drassodes lapidosus Walck.

Phrurolithus festivus C. L. K.

Xysticus luctuosus Bl. A single very young example found on the southern shore of the lake, near the Black Wood.

Lycosa amentata Clerck.

„ *agricola* Thor.

Trochosa terricola Thor.

Theridion pallens Bl.

Savignia frontata Bl.

Minyriolus pusillus Wid.

Styloctetor penicillatus Westr.

Œdothorax apicatus Bl.

Pœciloneta globosa Wid.

Leptyphantes terricola C. L. K.

„ *tenebricola* Wid.

„ *obscurus* Bl.

„ *ericæus* Bl.

Linyphia montana Clerck.

Tetragnatha extensa L.

On June 9th, Schiehallion was ascended on an exceedingly stormy day with very heavy driving showers of rain and hail. The lower parts of the mountain are extremely exposed, and little could be done there. At one sheltered spot, about 2000 feet above sea-level, the following were found:—

Cryphæca silvicola C. L. K.

Robertus lividus Bl.

Walckenaëra acuminata Bl.

Centromerus prudens Camb.

Pœciloneta globosa Wid.

Leptyphantes Zimmermannii Bertk.

All the above were of the female sex. There was a good deal of shelter on the lee side of the summit, which has an altitude of 3547 feet, and here a couple of hours of cold but profitable work were accomplished. The results were as follows:—

Cryphæca silvicola C. L. K.

Robertus lividus Bl.

Savignia frontata Bl.

Hilaira frigida Thor. Both sexes fairly common.

Macrargus adipatus L. Koch. A male and several females.

Diplocentria rivalis Camb. One male.

Leptyphantes Whymperei F. Camb. Both sexes adult and many immature examples.

Leptyphantes cacuminum sp. nov. Several females. See note on p. 118.

Nemastoma lugubre O. F. Müll.

Obisium muscorum Leach.

On June 12th, an excursion was made over the lower slopes of Beinn-a-Chuallaich. The water-course Allt Mor was first ascended, and then by walking obliquely upwards and westwards the top of the ridge was gained at an altitude of about 2000 feet. This was some way west of the actual summit. The steep western face of the mountain was descended, and a little glen containing numerous birch trees was traversed. Finally the road on the north side of the lake was entered about a mile and a half west of the Loch Rannoch Hotel. The following Arachnids were noted:—

Drassodes lapidosus Walck.

„ *trogloodytes* C. L. K.

Clubiona trivialis L. K. A male, at about 1700 feet.

Zora nemoralis Bl. A female, in the glen at the foot of the mountain.

Cryphœca silvicola C. L. K.

Tarentula pulverulenta Clerck.

Lycosa pullata Clerck.

„ *nigriceps* Thor.

Ciniflo fenestralis Strœm.

Theridion bellicosum Sim. Both sexes. This species had not previously been recorded as inhabiting the British Isles. See note on page 123.

Robertus lividus Bl.

Walckenaëra acuminata Bl.

Evansia merens Camb. A male and several females, in ants' nests in the glen at the foot of the mountain.

Maro F. Iconerii Jackson. A female, under a stone in the same glen. New to Scotland.

Pœciloneta globosa Wid.

Leptyphantes ericæus Bl.

Labulla thoracica Wid.

Linyphia pusilla Sund.

Ooisium muscorum Leach.

Megabunus insignis Meade.

Mitopus morio Fabr. Immature examples.

Centromerus bicolor Bl. A female was brought to me on the same day from Glen Lyon.

On June 13th, whilst waiting at Rannoch Station for a train, the following were obtained on Rannoch Moor :—

Peponocranium ludicrum Camb. One male.

Macrargus abnormis Bl.

Agyneta cauta Camb. Females.

A couple of hours on June 13th and the whole of June 14th and June 15th were devoted to Ben Nevis. The following species were taken at low elevations, all of which were under 2000 feet :—

Segestria senoculata L.

Oonops pulcher Templ.

Clubiona trivialis L. Koch. Lochan Meall-an-t'-Suidhe.

Neon reticulatus Bl.

Tarentula pulverulenta Clerck.

Lycosa pullata Clerck.

„ *amentata* Clerck.

„ *nigriceps* Thor.

Robertus lividus Bl

Pholcomma gibbum Westr. At foot of mountain.

Gonyliidiellum vivum Camb. At foot.

Walckenaëra nudipalpis Westr. Lochan Meall-an-t'-Suidhe.

Tapinopa longidens Wid.

Epeira diademata Clerck.

Obisium muscorum Leach.

In the scree bed above the half-way house, from about 2000 feet to 2200 feet, the following occurred :—

Cryphœca silvicola C. L. K.

Robertus lividus Bl.

Theridion bellicosum Sim. Females only.

Theonoe minutissima Camb. One female.

Diplocephalus castaneipes Sim. One female.

Walckenaëra capito Westr. Two examples of what is believed to be the female of this species.

Centromerus prudens Camb.

Macrargus abnormis Bl.

Leptyphantes Zimmermannii Bertk.

„ *Whymperii* F. Camb. Both sexes. This species had not before been found under 2900 feet.

Mitopus morio Fabr.

Nemastoma lugubre O. F. M.

Obisium muscorum Leach.

A number of species occurred under stones, from about 3500 feet to 3700 feet. These included :—

Leptyphantes Whymperii F. Camb.

„ *cacuminum* sp. nov.

„ *Zimmermannii* Bertk.

Pœciloneta globosa Wid.

Micryphantes sublimis Camb. One female.

Macrargus adipatus L. Koch. Both sexes.

Hilaria frigida Thor. The commonest species at this altitude.

Coryphœus mendicus L. Koch. One male. New to Britain. See note on page 127.

Erigone tirolensis L. Koch. Both sexes. New to Britain. See note on page 126.

Tiso æstivus L. Koch. A pair of adults. New to Britain. See note on page 127.

Entelecara errata Camb. Both sexes. New to Scotland.

Styloctetor morula Camb. Females. Recorded from the Cheviots in Northumberland, but not before from Scotland.

Nemastoma chrysomelas Herbst. Both sexes.

Obisium muscorum Leach.

The actual summit, which is 4406 feet in altitude, was covered with twelve feet of snow on June 14th. Near it, however, were several exposed places covered with stones. Under these stones on these “islands,” at elevations of from 4000 feet to 4200 feet, the following spiders were found :—

Leptyphantes Whymperii F. Camb. Common.

„ *cacuminum* sp. nov. Not rare.

Hilaria frigida Thor. Common.

Macrargus adipatus L. Koch. One male.

Coryphœus mendicus L. Koch. Both sexes, the females being common.

Styloctetor morula Camb. One male.

Ben Nevis appears to me extraordinarily rich as regards its spider fauna. It easily surpasses in this respect the mountains of Cumberland, and the

Snowdon range. Almost all the known mountain spiders of Britain were found on it in a very short period, the conspicuous absentees being *Leptyphantes pinicola* Sim., *Cornicularia Karpinskii* Camb., *Trochosa biunguiculata* Camb., and *Amaurobius atropos* Walck. The last is rather an extraordinary omission, as it is so abundant on the mountains of the English Lake District. Three species new to Britain were discovered.

On June 16th, the following were picked up on the rocky shore of Mallaig harbour :—

Segestria senoculata L.
Drassodes lapidosus Walck.
Heliophanus cupreus Walck. Both sexes.
Evophrys frontalis Walck. Both sexes.
Textrix denticulata Oliv. Both sexes.
Pirata piratica Clerck.
Tarentula barbipes Sund. Immature.
Lycosa amentata Clerck.
 „ *pullata* Clerck.
 „ *nigriceps* Thor.
Ciniflo fenestralis Ström.
Epeira diademata Clerck.

On June 17th, the following were picked up during the passage of the Crinan Canal :—

At the salt marsh, near Crinan :

Pirata piratica Clerck.
Lycosa amentata Clerck.
 „ *purbeckensis* F. Camb. Small form. A female. In this sex the diagnosis from *L. monticola* C. L. K. is doubtful, but the nature of the locality makes it almost certain that it is the species named.
Ceratinella brevipes Westr.
Edothorax fuscus Bl.
Maso Brittenii Jackson. A single example of what is believed to be the female of this species. Both sexes have not as yet been taken together. New to Scotland.

Halfway through the canal in a little wood were :

Lycosa amentata Clerck.
Robertus lividus Bl.
Leptyphantes tenuis Bl.
Walckenaëra acuminata Bl.

On the shore at Ardrishaig the following were captured :

Lycosa amentata Clerck.

„ *agricola* Thor.

Erigone arctica White. Females only.

Macrargus abnormis Bl.

Platybunus corniger Herm.

II.—DESCRIPTION OF SPECIES.

Leptyphantes cacuminum sp. nov.

[Plate II. Figs. 1, 2, 3, 4, 5 and 6.]

MALE.—Total length, measured in profile, 1·75 mm.

Colour.—*Carapace*—Clear yellow-brown, with slight traces of a dark marking at the thoracic juncture giving off radiating lines to the edges of the cephalothorax. *Sternum*—Yellow-brown, much suffused with dark brown; in some specimens of an almost uniform dark brown. *Labium and appendages* yellow-brown, the palpal tarsi being the darkest. *Abdomen* yellow-brown, more or less suffused with dark brown. No dentated pattern, but in some dark specimens the dorsum bears three or four pairs of pale round spots arranged in two longitudinal rows, and a few pale streaks. Under part of abdomen yellow-brown; the epigastric area sometimes, and the spinners always, a good deal paler than the rest.

Eyes.—Arranged in two rows.

Anterior row straight. Centrals almost in contact and about a diameter from the laterals, which exceed them in size.

Posterior row straight. Eyes subequal. Centrals less than a diameter apart and still nearer to the laterals. Ocular area much pigmented. These ocular arrangements are subject to considerable variation as in all spiders of this family.

Clypeus.—About as high as ocular area.

Sternum.—Heart shaped.

Labium.—Short, rounded in front.

Falces.—Rather divergent.

Palpi.—*Patella*—Short, ·1 mm. long, with a prominent gibbosity above, from the summit of which springs a strong bristle.

Tibia—Longer than patella, measuring ·13 mm. Gibbous above, rather in front of the middle. Posterior to this gibbosity arises a long, strong bristle similar to that carried by the patella.

All these measurements are made from the outer side, but in Plate II. fig. 1 the foregoing articles are not shown in profile, and so do not appear to have the shape here described.

Tarsus.—3 mm. in length, gibbous dorsally behind.

Paracymbium.—Large and complex. It bears two prominent black teeth, one projecting forward from the posterior border, the other upwards from the ascending ramus.

Lamella characteristica.—In the shape of a large, shining, curved band. This has a complicated termination ending in a large, sharp point placed below a bunch or brush of minute bristles, the size of which is exaggerated in Fig. 1.

Embolus.—Large, thick, and directed upwards.

Legs.—*Femora*.—The first femur bears a spine near the apex on the dorso-internal surface. Remaining femora unarmed.

Patellæ.—Each bears a spine above.

Tibiæ.—Each bears two dorsal spines. The first tibia bears in addition an anterior lateral and a posterior lateral spine, about the level of the distal dorsal spine. The second tibia bears a posterior lateral spine only, at this level. Remaining tibiæ without lateral spines.

Metatarsi.—Each bears a single spine dorsally nearer the base than the apex. Lateral spines absent.

FEMALE.—Length, 1·8 mm. to 1·9 mm. The female is slightly larger than the male and has a much more convex and rotund abdomen, which is usually of a lighter colour. General characters and leg armature as in the male.

Falces.—Shorter and less divergent. The anterior border of the fang groove bears three strong teeth, of which the distal is the largest and the proximal the smallest. The posterior border bears four very minute closely-grouped denticles.

Epigyne.—Highly characteristic. Seen from beneath, this appears as a very large projection of hairy, almost unmodified, integument which springs from the epigastric region and reaches the middle of the ventral surface of the abdomen. Viewed from the side, a pale chitinized area can be seen, and also a small curved process springing from the lower border and running backwards and downwards. These structures are, however, best seen from below and behind, whence they appear as represented in Fig. 6.

Several females of *L. cacuminum* were taken under stones at 3500 feet, near the summit of Schiehallion, on June 9th. On June 14th, more females and a few males were obtained on Ben Nevis, between 3700 feet and 4200

feet. Careful search below the former altitude produced no examples, whilst above the latter the ground was covered with snow. Most of the specimens were found under stones on bare patches of ground surrounded by masses of snow. During the major part of the year the species, together with other spiders occurring in the same place, must be completely snowed up. The inferior height and extremely graceful and pointed summit of Schiehallion renders that mountain not so favourable to the accumulation of thick deposits of snow.

Robertus scoticus sp. nov.

[Plate II. Fig. 15.]

FEMALE.—Total length, 2 mm.; cephalothorax, .84 mm.

Carapace.—Dark yellow-brown. Traces of a darker marking at the thoracic juncture, with radiating lines present.

Eyes.—In two rows.

Anterior row straight. Centrals by far the smallest and darkest.

Centrals almost in contact much less than a diameter from laterals.

Posterior row straight, or very slightly curved, with convexity behind.

Centrals slightly less than laterals. All eyes about a diameter apart. Ocular area much pigmented.

Clypeus.—Dark yellow-brown, about as high as ocular area. In profile the thoracic juncture is very distinctly the highest part. Thence the dorsum slopes down evenly and gradually to the ocular area, which is not at all prominent. Backwards the dorsum slopes down rapidly to the peduncle in a curve concave behind.

Sternum.—Heart-shaped, yellow-brown, ornamented with dark brown streaks. Termination not passing the last coxæ.

Labium and maxillæ.—Dark yellow-brown.

Palpus.—Yellow-brown, darker on the last two articles. Tarsus clawed.

Legs.—Yellow-brown, with tarsi and metatarsi darker.

Abdomen.—Yellow-brown, much suffused with brown pigment above. This is arranged in a somewhat reticular pattern, enclosing many small round spaces which show the lighter ground colour; below more irregularly pigmented.

Book-leaf trachea.—Pale yellow-brown, each bordered by a darkly pigmented zone.

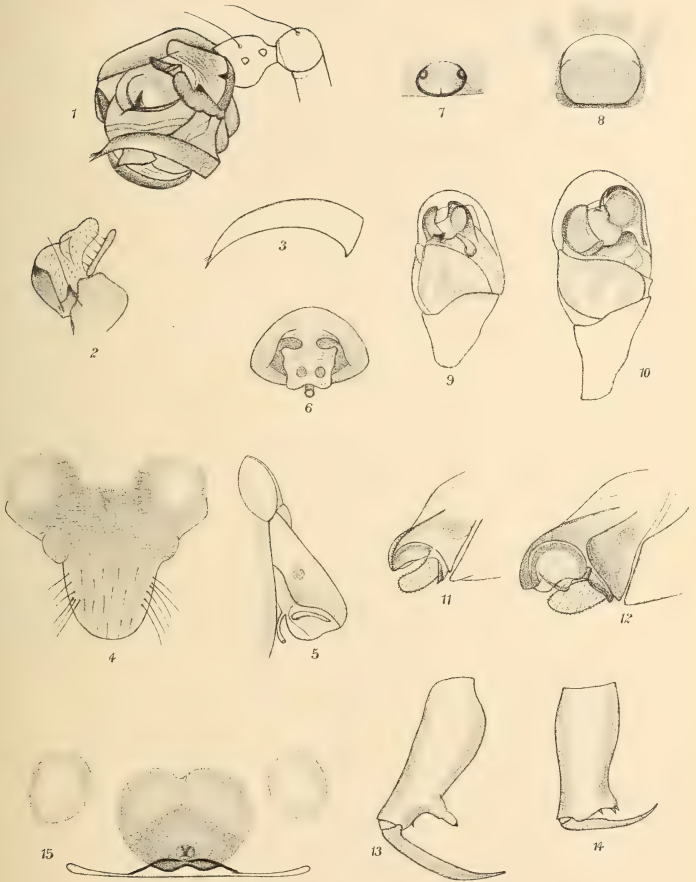
Spinners.—Pale yellow-brown.

Epigyne.—Highly characteristic. Sexual aperture placed near the

PLATE II.

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posterior margin of a central, cordiform, pigmented area. The posterior termination of this area forms a prominent bilobed lip. Length from anterior end of heart-shaped area to posterior margin of lip, .21 mm.

A single female was found on June 10th, amongst moss, in the Black Wood of Rannoch.

This species closely resembles the common *Robertus neglectus* Camb. in size, colour and facies. It differs entirely in the structure of the epigyne from that species.

The only figure of this structure in *R. neglectus* known to me is that of Mr Cambridge, in *Spiders of Dorset*, plate vi. fig. 7d., sub *R. astutus* Camb.

In this species the central pigmented area is roughly circular, and the sexual aperture is placed in the middle or between the middle and the anterior margin, considerable variation in this respect being shown. The details of the aperture are quite different in the two species, and in *R. neglectus* there is no bilobed posterior termination of the epigynal area.

The epigyne figured by Bösenberg, in *Die spinnen Deutschlands*, fig. 183, as that of *Pedanostethus Clarkii* Camb. (*sic*), is quite unlike that of either species.

Professor Kulczynski, who kindly examined the specimen of *R. scoticus*, tells me his figure in *Aranee Hungariae* does not represent the vulva of the true *R. neglectus* Camb., but some other species.

In all the specimens of *R. neglectus* in my collection the slope of the carapace, as seen in profile, is much more regular than in *R. scoticus*. The thoracic juncture in no case is the highest point, that being rather nearer the caput. The whole curve is as a rule pretty regular, though there may be a slight concavity between the thoracic juncture and the peduncle. The unusual shape in *R. scoticus* may of course be only an individual peculiarity.

Genus THERIDION.

The discovery of a small *Theridion* on the mountains of Scotland has made it clear that two species have been included by some continental writers under the name of *T. lepidum* Walck. One of these, described by Mr Cambridge as *Theridion instabile*, was already known in Britain; the other, which I am now recording as *T. bellicosum* Sim., is recorded here for the first time. As the result of a correspondence with Mr O. Pickard-Cambridge, Mr Simon and Professor Kulczynski, none of whom expressed exactly similar views, though all were in general agreement, I am now abandoning the name *T. lepidum* Walck. altogether. It seems plain that it is impossible to decide which of these species is meant by the original

description, or whether indeed this does not relate to the common *T. lineatum* Clerck, quite another species. I am now introducing *T. bellicosum* Sim. as new to Britain, and proposing to call that southern form, which we have hitherto called *T. lepidum* Walck., by the name of *T. instabile* Camb.

These two species resemble each other in many particulars, and these I shall not describe. I shall endeavour, however, to point out the numerous differences between them.

T. bellicosum and *T. instabile* differ in the following respects:—1, size; 2, colour; 3, proportions; 4, sexual organs; 5, male falces.

Theridion instabile Camb.

[Plate II. Figs. 8, 10, 12 and 13.]

Theridion instabile Camb. Trans. Linn. Soc., xxvii., p. 416, pl. 55, No. 14.

Size.—Total length of male, 2·2 mm.; of female, 2·2 mm. to 2·7 mm. The latter female was much distended with ova.

Colour.—Similar in both sexes. *Carapace*.—Clear yellow-brown with a broad distinct dark brown central marking. This extends from the posterior end of the cephalothorax to the ocular area, which it generally passes, in these cases tingeing the clypeus. It is parallel sided, or slightly expanded at the ocular area. The *sternum* is clear yellow-brown. These colours are practically invariable in all my specimens. *Abdomen*.—Very variable. The commonest arrangement for the upper side is its occupation by a large oval dark brown patch. This may be immaculate, or it may bear a central dentated band which, in all my specimens, is very narrow. The dark patch may be absent, and the central band may appear on a yellow-brown background; or the abdomen may be of a pale yellow-brown colour, bearing a few pairs of dark blotches arranged longitudinally. Irregular white spots may ornament the whole or any part of the abdomen. Below, the abdomen is yellow-brown, the epigastric area not usually darker than the rest. Between this and the spinners a dark marking is nearly always present. In the male this takes the form of a transverse oblong, and in the female usually of an isosceles triangle with the apex pointing backwards. Occasionally, however, in the female the shape is oblong, or irregular, and sometimes even the whole mark is absent.

Proportions.—The differences here are perhaps not very important. The average height of clypeus in the male is ·22 mm. The shape of the carapace of the male, as seen in profile, is rather characteristic. There is a gradual rise from the peduncle to the thoracic juncture, then a marked dip at the occiput, and finally a sudden rise at the caput.

Sexual organs.—*Palpi*—Average measurements from outer side.

Patella—·18 mm.

Tibia—·22 mm.

Tarsus—·36 mm.

The structures at the apex of the palpal organs are characteristic. The outer apophysis seen from below is nearly circular, and possesses a small fold of membrane on its inner side (see Plate II. figs. 10 and 12).

The *epigyne* measures ·09 mm. in length by ·145 mm. in breadth; its structure is characteristic (see Plate II. fig. 8).

Falces.—In the male sex these are extremely long and divergent. A long, strong apophysis is placed in the apical half of the basal joint, at the inner side. Distal to this the article is continued for some distance as a cylindrical body. The apophysis bears one very minute tooth near its apex, and there is another similar one between the apophysis and the apex of the article. In small under-developed specimens the distance between apophysis and apex is less than in figure 13, which represents an average well-developed individual.

T. instabile Camb. occurs in swampy places in the south of England, and I have seen specimens from County Carlow in Ireland.

Theridion bellicosum Sim.

[Plate II. Figs. 7, 9, 11 and 14.]

Theridion bellicosum E. Sim. Aran. nouv., etc., Mém. Soc. Roy. sc. Liège, 2^e mém. p. 106.

Size.—Total length of male, 1·6 mm.; of female, 1·8 mm.

Colour.—*Carapace*—Clear yellow-brown. In the male this may be immaculate, or there may be a faint dark marking at the thoracic juncture, taking the form of a short triangle with the apex in front. This never reaches the ocular area. In the female this mark is better developed, though still faint. It generally takes the form of a broad quadrilateral almost square patch, scarcely reaching the occiput. In no specimen of either sex did this faint mark approach the ocular area. *Sternum*—Yellow-brown, much suffused with dark brown. *Abdomen*—The colour is variable, but almost always there are traces of a broad, pale, dentated, central, longitudinal band. The dentations are generally divided by three or four pairs of dark brown blotches arranged longitudinally. The ground colour varies from dark brown to yellow-brown. Below, the abdomen is pale yellow-brown, with the epigastric area more deeply pigmented. Between this and the spinners is an oblong transverse dark patch apparently never triangular. The colours are very similar in the two sexes. In spirit the abdomen of the female is apt to collapse in the middle line below, producing a deep longitudinal furrow.

Proportions.—Average height of clypeus in male, .23 mm.

Seen in profile the carapace of the male forms a fairly regular curve, the occipital dip and sudden rise of caput not being present. This, however, is probably rather variable.

Sexual organs.—*Palpi*.—Average measurements from outer side.

Patella.—13 mm.

Tibia.—19 mm.

Tarsus.—31 mm.

The external apophysis at the apex of the palpal organs is far from circular, in most positions appearing more pointed.

Epigyne.—This measures .04 mm. long and .07 mm. broad. It is thus less than half the size of that of *T. instabile* Camb. Its structure, too, is markedly different (see Plate II. fig. 7).

Falces.—In the male sex these are only slightly divergent, and much shorter than in *T. instabile* Camb. There is a large apophysis on the inner side of the basal joint, near the apex. This bears two or three teeth. Another tooth is placed between the apophysis and the apex. These teeth are actually larger than those in the bigger species, *T. instabile*. Distal to the apophysis the article slopes rapidly and obliquely to the apex, some variation in the rapidity of the slope being observable.

Both sexes of *T. bellicosum* Sim. were found on Beinn-a-Chuallaich, on June 12th, at about 1700 feet. On June 15th, females occurred on Ben Nevis. In both localities the specimens were found under stones, the females carrying about their spherical white egg-sacs attached to their spinners.

The two species then differ in size, colour, proportions (the smaller one having actually a higher clypeus than the larger one), palpi, vulvæ and male falces. They differ equally in habits, one living in the southern marshes and the other on the bare Scottish mountains.

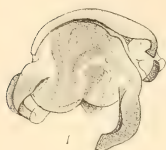
Mr Simon has kindly examined both forms for me and states that the smaller one is identical with his *T. bellicosum*. This was also Professor Kulczynski's belief, but he informed me that it was also his *T. lepidum* Walck. of the *Araneæ Hungariæ*. I think, from Dr de Lessert's figure in *Catalogue des Invertébrés de la Suisse*, there is no doubt that his *T. lepidum* Walck. also represents the form here called *T. bellicosum* Sim.

T. instabile Camb. is recorded from the Lake District of North Lancashire and from St Kilda. I have never seen these specimens so am unable to say to which form they belong.

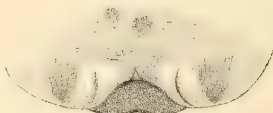
PLATE III.

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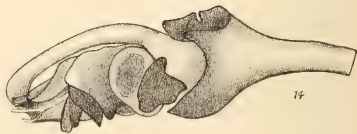
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13



8



14

Zilla Strœmii Thor.

[Plate III. Figs. 1 and 2.]

- Zilla montana* C. L. K. Westr., *Aranæe Svecicæ*, pp. 73, 74, 75.
Zilla Strœmii Thor., Remarks on Synonyms of European Spiders, pp. 34, 35, 36.
" " " Sim., *Arach. de France*, i., pp. 144, 145.
" " " Chyz. and Kulcz., *Aranæe Hungariæ*, i., p. 137, Tab. v.
fig. 30 a, b.
" " " Bösenb., *Die Spinnen Deutschlands*, 45, Taf. iii. fig. 34, A, B, C.
" " " de Lessert., *Catalogue des Invertébrés de la Suisse*, fas. 3;
Araignées, p. 343.

This species, which is well known on the Continent, has occurred in France, Switzerland, Germany, Hungary, Sweden, Lapland and Russia. This is its first record in Britain. The structure of the palpi and epigyne easily distinguish it from all its congeners. The abdominal pattern, whilst resembling that of the two common species, is sufficiently distinct to render the species recognisable to the naked eye. See figure in Bösenberg, *loc. cit.* The present species is adult in June, and presumably July, whilst the others are in this country rather sharply autumnal animals. *Z. Strœmii* occurred commonly on the trunks of pines in certain spots in the Black Wood of Rannoch. The webs, which resembled those of our common species in having a free radius, were spun on the trunks of the trees from a foot or two above the ground to a height of at least seven or eight feet. Only three adult males were found and nearly a score of adult females. A great number of both sexes were immature individuals of different sizes. The species was very local in the wood, the best place being a clump of young pines growing in a swamp close to the road, almost opposite the sixth milestone from Kinloch Rannoch.

Clubiona subsultans Thor.

[Plate III. Figs. 3, 4 and 5.]

- Clubiona erratica* C. Koch. Westr., *Aran. Svecicæ*, pp. 397, 398.
" " " Sim., *Arach. de France*, iv., pp. 229, 230.
" " " Thor., Rem. on Synonyms of European Spiders, pp. 222,
223.
" *subsultans* Thor. 1875. Verzeich. Sud-Russ. spinnen.
" " " Bösenb., *Die Spinnen Deutschlands*, pp. 278, 279, Taf. xxvi.
fig. 409, A, B, C, D.
" " " Chyz. and Kulcz., *Aranæe Hungariæ*, ii., p. 226, Tab. ix.
figs. 2, 23, 35.

This species is known from France, Germany, Hungary, Tyrol, Sweden and Russia, but this is its first British record.

The palpal organs and tibia of the male easily separate the species from its near congeners *C. grisea* L. K. and *C. reclusa* Camb. The females are more difficult. Professor Kulczynski has kindly sent me both sexes from Hungary, and so there is no doubt of the identity of my Scottish examples. I have figured here the epigyne of the female as I see it, but I must admit it is very different from the figure in *Aranæe Hungariæ*, although Scottish and Hungarian examples agree quite well in that respect. Continental writers claim that the female of this species possesses a long, dorsal, lanceolate mark in the middle line of the abdomen, which reaches the spinners, and which is absent in the allied species. This is certainly well marked in the Hungarian examples, but is not nearly so distinct in the Scottish specimens. In examining a fairly long series of British females of *C. grisea* L. Koch, a similar marking was found in several examples. The colour of the abdomen of the Scottish *C. subsultans* is rather warmer, inclining more to reddish-brown, than in *C. grisea*; but, in the absence of the male, I should certainly hesitate to record *C. subsultans* in a new country. Fortunately in this case a male was found.

A male and two females of *C. subsultans* Thor. were found on the bark of pines in the Black Wood of Rannoch when looking for *Zilla Stræmii*. Probably if carefully worked for the species would be found more abundantly.

Erigone tirolensis L. Koch.

[Plate III. Figs. 12, 13 and 14.]

- Erigone tirolensis* L. Koch., Beitr. z. Kennt. Arach. Tirols, ii.
 " " " Chyz. and Kulcz., Aran. Hungariæ, ii., p. 90, Tab. iii.
 fig. 37 a, b, c.
 " " " Kulcz., Erig. Europææ addend. ad descriptiones, figs. 10,
 26, 40, 52.
 " " " de Lessert, Catalogue des Invertébrés de la Suisse, f. 3;
 Araignées, pp. 202, 203.

This species has occurred in Tyrol, Siberia, Tatra, and in Switzerland at 2700 metres.

The male measures 2·2 mm. in total length, and closely resembles in facies many other species of the genus. The structure of its palpi, however, will separate it from those, and quite easily from all those known at present to inhabit Britain. The females are difficult, as are all those of the genus *Erigone*, but the epigyne is more characteristic than are those of most of the species, and I think this sex should be recognised when found. Both sexes were found, on June 15th, on Ben Nevis at about 3500-3700 feet. The species occurred under small stones in places which were damped by little streams

of water trickling from the melting snow above. At that date their locality was below the snow-line.

Professor Kulczynski kindly confirmed my identification.

***Tiso æstivus* L. Koch.**

[Plate III. Figs. 9, 10 and 11.]

Erigone æstiva L. Koch., Beitr. z. Kennt. Arach. Tirols, ii.

Erigone carpatica Kulcz., Aran. Nov. in mont. Tatricis, etc., pp. 16, 17, Tab. ii. figs. 10 a, b.

Tiso æstivus L. Koch. Chyz. and Kulcz., Aran. Hung., ii., p. 127, Tab. v. figs. 7 a, b, c, d, e.

This species is recorded from Tyrol and Tatra in the Carpathian mountains. Its place appears to be taken in the Swiss and French Alps by *Tiso morosus* Sim., which must be very closely allied.

A very distinct little species, the male of which measures 1·3 mm. in total length. Facies rather like that of *Tiso vagans* Bl. The figures of the palpi in *Araneæ Hungariæ* are excellent, but the vulva appears different to me, and I have tried to draw it as I see it.

Professor Kulczynski kindly confirmed my identification.

A pair of adults were found on Ben Nevis at about 3500 feet, near the locality inhabited by *Erigone tirolensis*.

***Coryphæus mendicus* L. Koch.**

[Plate III. Figs. 6, 7 and 8.]

Erigone mendica L. Koch., Arachniden aus Siberien und Novaja Semlja.

Coryphæus mendicus L. Koch. Kulcz., Fragmenta Arachnologica, v., pp. 585-588, pl. xxi. figs. 11, 16, 17, 18, 19.

This species inhabits Siberia. I can find no other records.

The male measures 1·8 mm. in total length. The species resembles *C. distinctus* Sim. in facies, but is darker in colour, being almost black. The structure of the genital organs easily separates the two species.

Males and females were found under stones near the summit of Ben Nevis well above the snow-line in June 1913. The highest was found at about 4200 feet, the lowest at about 3700, but at the latter altitude the species was very scarce. The actual summit was covered with snow, and the stones under which many of the specimens were found were surrounded by snow. This and other spiders at this altitude appear to feed chiefly upon a small Collembolan.

III.—EXPLANATION OF PLATES.

PLATE II.

1. *Leptyphantes cacuminum* sp. nov. Left palpus of male from outer side. Patella and tibia not seen in profile.
2. " " Paracymbium of left palpus from behind and outer side.
3. " " Lamella characteristica of left palpus from outer side.
4. " " Epigyne of female from beneath.
5. " " Epigyne, lateral view.
6. " " Epigyne from beneath and behind.
7. *Theridion bellicosum* Sim. Epigyne from beneath.
8. *Theridion instabile* Camb. Epigyne from beneath.
9. *Theridion bellicosum* Sim. Left palpus of male from beneath.
10. *Theridion instabile* Camb. Left palpus of male from beneath.
11. *Theridion bellicosum* Sim. Apex of left palpal organs from outer side.
12. *Theridion instabile* Camb. Apex of left palpal organs from outer side.
13. *Theridion instabile* Camb. Right falx from the front.
14. *Theridion bellicosum* Sim. Right falx from the front.
15. *Robertus scoticus* sp. nov. Epigyne and epigastric region from beneath.

PLATE III.

1. *Zilla Strömii* Thor. Left palpus of male from outer side.
2. " " Epigyne of female from beneath.
3. *Clubiona subsultans* Thor. Epigyne of female from beneath.
4. " " Tibia of right palpus from above.
5. " " Apex of right palpal organs from beneath.
6. *Coryphæus mendicus* L. Koch. Left palpus from outer side.
7. " " Tibia of right palpus from above.
8. " " Epigyne of female from beneath.
9. *Tiso æstivus* L. Koch. Epigyne of female from beneath.
10. " " Tibia of left palpus from above.
11. " " Left palpus from outer side.
12. *Erigone tirolensis* L. Koch. Tibia of left palpus from above.
13. " " Epigyne of female from beneath.
14. " " Left palpus of male from outer side.

(Issued separately, 14th February 1914.)

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XVII.—Notes on the Habits and Characteristics of Some Littoral Mites of Millport. By L. A. L. King, M.A., St Mungo's College, Royal Technical College, etc., Glasgow.¹

(Read 24th November 1913. MS. received 22nd December 1913.)

GAMASIDÆ—*Gamasus (Eugamasus) immanis*, Berl.

Gamasus (Halolaelaps) glabriusculus, Berl. et Trouessart.

BDELLIDÆ—*Molgus littoralis* (Linn.).

Bdella longicornis (Linn., 1758), Sig Thor, 1902.

THE mites to which the following notes refer were taken by the writer, on the shore in the immediate neighbourhood of the Marine Biological Station, Millport, Firth of Clyde.

The observations recorded were made partly upon the shore, partly in the station. In the case of *Eugamasus immanis*, a number of individuals were kept under observation from 23rd August to 26th September 1911, during the last fortnight of which period the writer was in Derbyshire, and received supplies of littoral Oligochæte worms from Millport as food for the mites.

For examination of the living mites the writer uses a Ross-Stephenson binocular microscope with a one-inch objective. For examination of structural detail, and for identification, he kills them with hot 70 per cent. alcohol, subsequently transferring them to 90 per cent. alcohol, and clearing with beech-wood creosote. From this, after examination, they can be mounted direct in Canada balsam dissolved in xylo, or they can be soaked in acid 70 per cent. alcohol to remove the oil, and subsequently preserved in 90 per cent. alcohol.

The coition of *Eugamasus immanis* was observed in a flat-bottomed watch-glass closed by a glass cover, a strip of paper being placed between the glasses at one point to admit air.

FAMILY GAMASIDÆ.

Gamasus (Eugamasus) immanis, Berl.

Gamasus (Eugamasus) immanis, Berl., was recorded for Millport in the "Annual Report of the Marine Biological Association of the West of Scotland," 1911, p. 69.² On page 33 of the same publication a preliminary

¹ Figs. 1-4, 6, 7 and 9 from camera lucida drawings; Figs. 5 and 8 from sketches.

² Mr Wm. Evans, F.R.S.E., tells me that he found this species on the shore of Loch Long, near Coalport, on 27th June 1910, and that he has taken it in the Forth Area since 1905.

note of observations on this species was given. The facts there recorded may be summarised as follows:—

Occurrence.—Under decaying seaweed, in “drift,” above ordinary h.w. mark, in damp situations.

Mating.—Observed during the last week of August, 1909 and 1911.

Coition.—Referred to more fully below.

Oviposition.—Occurred within a week of coition.

Form and dimensions of the ovum.—Oval, smooth, white or yellowish-white; 0·63 mm. \times 0·42–0·45 mm. in dimensions.

Hatching.—Took place about twelve days later.

General characters of the larva.—White, hexapod, active, not observed to feed; front legs tactile, as in adult.

First moult.—Occurred four days later, the fourth pair of legs appearing.

Habits of nymph.—Voracious, even attacking larvæ of its own species, but living mainly, like the imago, on small Enchytræid worms.

Habits of imagines.—Though eyeless, are sensitive to light and move away from increased illumination; discover food, and recognise sex of their companions, apparently by touch alone.

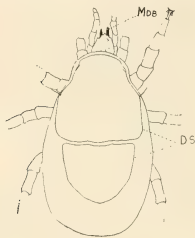


FIG. 1. *Eugamasus immanis*, female.

Outline of body and of dorsal shields, D.S.
Mandibles, MDB., shown partly retracted.

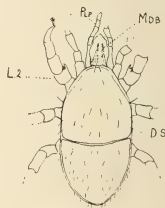


FIG. 2. *E. immanis*, male.

Dorsal view, showing in addition a palp, PLP.,
and one leg of the second pair, L.2.

The following observations are now added:—

Once identified, the species may be recognised at a glance by the large size of its individuals. They are giants amongst Gamasids, the female reaching a length of over 2·5 mm. and a breadth of over 1·6 mm., the male a length of over 2 mm. and a breadth of over 1 mm. The female is conspicuous by the broad white border surrounding the golden-brown shields (Fig. 1, D.S.) of horny integument that characterise the family. She has the appearance of having outgrown these armour plates, or of being distended in

the manner of a female *Ixodes*, though to a smaller degree. The white border is due to the translucency of the soft cuticle, through which the cæca of the mid-gut and other organs appear opaque white.

The male (Fig. 2) is of more slender form, golden brown in colour; its anterior and posterior dorsal shields being scarcely separated at the middle of the body. The surface bears a number of hair-like bristles distributed with some appearance of longitudinal linear arrangement. The legs of the second pair (Fig. 2, L2) are considerably thicker than the others, and bear on their concave surface a number of projections of characteristic form. These projections assist in the act of coition, as mentioned below. The individuals of both sexes are found walking about rapidly, and feeling their way by the tactile front legs. Males were not found, as a rule, in company with the females, except during the period in which coition was noticed. They seemed to prefer a drier situation than that favoured by the females.

FOOD AND METHOD OF FEEDING.

The situations frequented by the mites abound in Collembola, gnats and the larvæ of Muscid diptera, also in Turbellaria (*Gunda*) and small Oligochætes. Living specimens of all these were offered to them, but only the Oligochætes were attacked. Shreds of raw mutton proved acceptable after a two days' fast, and seemed to produce no evil consequences. Raw beef was tried by one of the mites, but this one died in the course of the next day.

In feeding on Oligochætes the mite uses its mandibles (chelicerae), which are chelate and are retractile into its body (Figs. 1 and 2, MDB.). The mandibles are plunged into the body of the worm, and the mite then tugs until a piece of the worm is broken off. Occasionally two individuals seize upon the same worm, and engage in a tug-of-war. The piece broken off is carried about by the mite, and its interior is torn and sucked till nothing but the cuticle of the worm remains.

CLEANING.

The palpi (Fig. 2, PLP.) are cleaned by being passed through the pincers of the mandibles, and also by being rubbed together. The legs of the first pair are "combed" by the palpi and, at the tip, by the mandibles. The abdomen is "combed" by the legs of the last two pairs.

COITION.

This process was described by Michael (1886) in the case of *Gamasus terribilis*, and (1892) in the case of *Hæmogamasus hirsutus*. In the latter the male seizes with his legs the third and fourth, or sometimes the second

and third, legs of the female, inverts his body beneath hers, and obtains a firm hold by laying the tarsi of his fourth legs on the dorsal surface of her abdomen. A flask-like hyaline sac or bubble ("spermatic capsule") then appears in the male genital opening and becomes distended with sperm-mother-cells ("spermatocysts"). His mandibles are exerted and placed one on each side of the capsule, which adheres to them by a viscid material that it has about it. The mouth of the flask is transferred to the genital opening of the female, and its contents are discharged into this opening by the elasticity of the capsule. The empty, shrunk capsule remains attached to the mandibles. The capsule and its contents are figured in the paper referred to, plate 33.

In the case of *Eugamasus immanis*, as observed by the present writer



FIG. 3. *E. immanis*, male.

Enlarged view of second leg of left side, viewed from the front.

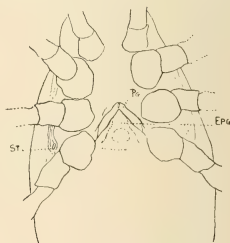


FIG. 4. *E. immanis*, female.

Enlarged view of a portion of ventral surface, showing plates which guard the genital opening —Paragynia, Pg., in front; epigynium, EPG., behind; also breathing apertures or stigmata, St.

who was not then acquainted with Michael's description, the process was similar in its general features. The male climbed, back downwards, beneath the body of the female, seized with his second leg of each side the corresponding fourth leg of the female, and secured a firm hold with the help of the "stridulatory spur" (Fig. 3, Sp.) on the third joint (femur) of his leg and of the stridulatory processes (Fig. 3, St.) on the fourth and fifth joints (genu and tibia). The writer has had no observation of the stridulatory function of these processes.

The mouth parts of the male were directed forward beneath the body of the female. The hind end of his body projected behind the extremity of the body of the female. The two hind pairs of legs of the male were relaxed and took no part in the holding. His front legs were held extended and his

palps (Fig. 2, PLP.) were not brought into use. The female continued to walk about carrying the male beneath. The mandibles (Fig. 2, MDB., in retraction) of the male were seen inserted deeply into the genital opening of the female, and between them was clasped a "spermatic capsule" (spermatophore), as described by Michael. The epigynium of the female (Fig. 4, EPG.) was raised during this process, and the mandibles of the male were inserted so far that the spermatophore was almost out of sight and completely within the endogynium or "vagina" (*cf.* Winkler, 1888, fig. 22). When the mandibles were withdrawn the capsule, now shrivelled and almost empty, remained attached to them. It was removed and examined, and was found to contain a few "spermatocysts" exactly similar to those figured by Michael in the case of *Laelaps vacua* (1892, pl. 33, fig. 28).

The males in captivity died a few days after coition. The females survived for several weeks. There is no evidence at present as to whether under natural conditions this union would terminate the existence of the

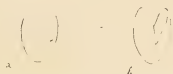


FIG. 5. Outlines of egg of *E. immanis*.

(a) entire ; (b) shell after hatching.

individual of either sex. Both were subjected to the same conditions as regards moisture and food.

NUMBER OF EGGS LAID.

A mated female, isolated on 4th September (1911), had laid two eggs by 5th September. Two females placed together on 2nd September had, between them, produced four eggs by 4th September, and no more by 5th September. On this date a male was placed with them, and by 6th September eight more eggs had been laid. Apparently two eggs were deposited, in succession, at each laying. The eggs required a considerable amount of moisture, otherwise they soon shrivelled. It was found convenient to supply this moisture by enclosing with the mites a piece of dark coloured rotting wood damped with sea-water. Upon this material most of the eggs were laid, and against its surface they were easily seen.

HATCHING.

This took place mainly at night, or when the vessel containing the eggs, a corked glass tube, was kept in the dark. The egg-shell was split longitudinally at the emergence (Fig. 5, b). The newly-emerged larvæ displayed

considerable activity, climbing away from the moisture condensed at the bottom of the tube, in which moisture one was nearly drowned. They made no attempt to feed upon the material offered to them, minute Enchytræids and crushed cocoon of the Earthworm. They retired into the crevices of the decaying wood upon which they had been hatched. In this retirement the first moult took place, and the first nymph, white and slender, but larger than the larva, emerged in search of food. Not meeting with anything else to eat it attacked one of the larvæ of its own species, which it reduced to an empty husk. It seemed to find this nourishing, as its outlines became more rounded, and it assumed a pinkish hue.

[*Note*.—A female *Eugamasus immanis* captured on 19th July 1912, oviposited the same day. Eggs have now been obtained, therefore, in three months, July, August and September]

DIAGNOSIS OF THE SPECIES.

Translated from A. Berlese, 1905, p. 179.

Gamasus (Eugamasus) immanis, Berl., n. sp. (1903).

(*Spicilegia Zoolog.* in "*Redia*," vol. i., n. 2, p. 262, 1903.)

Colour, yellowish; male to some extent tinged with golden brown. Male with legs of the second pair slightly thickened; femur (3) with a rather strong spur (which is) polliciform, incurved, acute at the apex (apical stridulatory radula); axillary process small, sharpened and subtruncate at the apex; genu (4) with a minute tuberculiform stridulatory process; tibia (5) with a process similar and scarcely longer, very slightly produced anteriorly. Tarsus with two rather stout spines at the apex. Epistome broadly triangular, acute in front, with saw-like arrangement of small teeth at the sides. Chela with the movable digit scarcely hooked, with a rather large tooth in the middle of its dentarial margin, otherwise edentulous; with the calcar in close contact with the digit. Fixed digit extending beyond the movable one, not incurved at the apex, ending in two sharp teeth, behind the apex with saw-like undulations, but without a strong tooth in the middle of the dentarial margin.

Female pyriform, stout; posterior dorsal shield almost of the form of an equilateral triangle, with undulate-rounded posterior margins, leaving a great part of the posterior dorsal surface uncovered. Epistome tapering to a subacute point, finely toothed at the sides and apex. Legs of the second pair with the extremity of the tarsi (6) armed with two spines as in the male. Epigynum elongate triangular, with undulate sides; paragnathia very narrow; sternal angle not clearly marked; endogynium subdiscoidal, simple; upper part of the uterine opening bordered with a single series of very small bristles. Chela larger than that of the male, with weak digits distinctly hooked; movable digit with equal teeth on its inner edge; the fixed one with two teeth beneath its apex, and then (at the sensory bristle) almost entire, farther back armed with two rather strong teeth.

A species of great size, the largest amongst its congeners.

Male up to 2350 μ in length; 1300 μ in breadth.

Female up to 2700 μ in length; 1750 μ in breadth.

Habitat.—Norway, Iceland.

Gamasus (Halolaelaps) glabriusculus, Berl. et Trouess.

? ? *Gamasus marinus*, Brady, A Review of the British Marine Mites, etc., 1875.

Halolaelaps glabriusculus, A. Berlese et Trouessart, Diagnoses d'Acariens nouveaux ou peu connus, 1889.

Zercon marinus, Moniez, Acar. et ins. marins des Côtes Boulonnais, 1890, p. 13.

The writer had frequently noticed a Gamasid mite, on and under stones between tide-marks, at Millport, but it was not until July 1912 that he secured adults of both sexes in addition to the nymphs which are more commonly found. They agreed in detail (Fig. 6: *a*, female; *b*, anterior margin of epistome of a male) with Berlese's diagnosis, as quoted below from the *Monografia*, 1905. Berlese notes (1905, p. 110)—

"Lives on the sea-shore under seaweed; fairly frequent in France, Spain (and in Britain?)."

He refers, p. 111, to Moniez's mention of it as very common on the *Fucus* which covers the rocks invaded by the sea. Moniez cites Brady (1875) who found his *Gamasus marinus* in the crevices of magnesian limestone rocks, between tide-marks, near Sunderland, and (a single example) washed from among the roots of algæ dredged off the isle of Cumbrae in the Firth of Clyde. This would signify that the species could live constantly submerged.

It must be mentioned that Brady (1875) gives the length of his specimens as one-twelfth of an inch, which is more than 2 mm. The extreme length of the specimens seen by Berlese is 950 μ , and the average is about 800 μ . Two females from Millport, now exhibited, measure each approximately 820 μ long, 460 μ broad. The short description given by Brady, and the figure of a palp, a mandible, and a labial cornicle of a Gamasid do not seem in themselves to justify Moniez's confident ascription of his example to that species.

Apart, then, from the consideration of the identity of his species, Brady's note is of interest as raising the question whether a Gamasid can live constantly submerged by the sea. Upon this the following observations may throw some light.

The mites, identified from Berlese's description and figures as *Gamasus (Halolaelaps) glabriusculus*, are found at Millport under stones covered with *Chondrus crispus*, or with *Cladophora rupestris*, and having an incrustation of Sponges, Polyzoa, Hydroids, minute Annelids and Nematodes, particularly those stones between half-tide limit and the upper boundary of the Laminarian zone. They are active on these stones when just left by the tide, but are not found moving about on stones taken from under water

except where these are hollowed out by cavities containing air. They are not found wandering on stones taken from rock pools.

On 16th July 1912 some of these mites were placed under water in glass vessels. They remained at the bottom, motionless except when touched. The peritreme tubes (Fig. 7, Pt.) had a silvery appearance by reflected light, indicating that they contained air. When taken out of the water these individuals became active and began to walk about immediately.

Several specimens kept under water till 11 A.M. the next day were then found to be dead. On 23rd July a number of the mites were placed on a stone, surrounded and partly covered by salt water, in an earthenware dish. They confined their wanderings to the part of the stone not submerged.

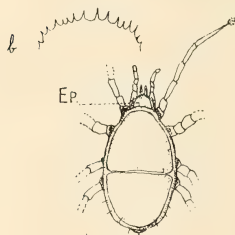


FIG. 6. *Halolaelaps glabriusculus*.

(a) Outline of body of female in dorsal view.

(b) Enlarged drawing of anterior margin of "upper lip" or epistome, Ep., from a male specimen.

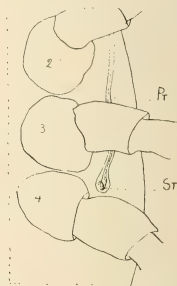


FIG. 7. *H. glabriusculus*.

Enlarged drawing of a portion of ventral surface of female, showing stigma, St., peritreme tube, Pt., and the bases of second, third, and fourth legs of left side, 2, 3, 4.

On the following morning, some of them were found sheltering on the under surface of the stone where the water did not cover it. Others were walking on the top of the stone. One seemed to be feeding, but the food particle was lost in the transference of the mite to a watch-glass, and no identification could be made. The apparent range of probable food substances included Polyzoa (*Lepralia* and *Schizoporella*), Hydroids (*Sertularia* and *Clava*), minute Annelids, and Halacarids.

It was noticed that the mites when walking on a wet surface of the stone stopped frequently and seemed to rub the water from their legs and palps.

At 10 P.M., on 24th July, a female specimen was isolated and placed under water. It remained alive, though motionless, and only struggling in

a helpless way when touched, till 10 A.M. on 26th July, when it was released. Another specimen isolated under the same conditions, also for forty-eight hours, gave the same result. The mite when released was lethargic in each case.

It is evident, then, that *Halolaelaps* can endure complete immersion for at least forty-eight hours, but that during this time it is not living the life of an aquatic organism, but is merely exhibiting what Plateau (1890, p. 268) noticed as "a general property of abranchiata Arthropods, which all, or almost all, resist asphyxia for a remarkably long time."

The facts to which attention is called in this particular case are the presence of air in the peritreme tube of the mite, and the possibility under the ordinary conditions of its life of its finding, during the hours of tidal submergence, a reservoir of air in the crevices of the stones or amongst the encrusting organisms of its habitat.

DIAGNOSIS OF THE SPECIES.

Translated from A. Berlese, 1905, p. 109.

Gamasus (Halolaelaps) glabriusculus, Berl. et Trouess.

? ? *Gamasus marinus*, Brady, 1875.

Halolaelaps glabriusculus, A. Berlese et Trouessart, Diagnoses d'Acariens nouveaux ou peu connus, 1889.

Zercon marinus, Moniez, Acar. et ins. marins des Côtes Boulonnaises, 1890.

Colour, brownish-golden; ovate, scarcely shouldered, rounded behind. Integument quite conspicuously areolate. Body-hairs very short (except some of the posterior ones, especially an unpaired postanal one), subspiniform, few. Male with the legs of the second and third (pairs) scarcely thicker than the others, furnished with spurs. Femur of the second pair with a conical spur below (which is) short and directed outwards, also a rather strong spine; genu and tibia unarmed; tarsus with below two equal conical spurs, (which are) subacute at their apex. Femur of the third pair with a short spur below, (which is) conical, acute; genu with a rather strong process below under its apex, the rest of the same genu faintly roughened with tubercles below; tibia unarmed; tarsus armed, in the middle of its side, with a rather large, weak tooth. Femur of the first pair armed below, almost at its base, with a stout hooked tooth directed forwards. Epistoma in either sex well chitinized, rounded in front and deeply and irregularly serrulate on its whole anterior margin with numerous small teeth. Chela of the male very small, slender, with weak digits distinctly hooked at their apex: fixed digit straight, the more slender, almost entirely toothless, but armed in the anterior third part of the dentarial margin with two quite large teeth; movable digit slender, but quite broad at its base, with a single rather large tooth beneath the hook: calcar narrow, standing well out from the inner base of the movable digit, at first folded inwards, then directed outwards, and finally reaching the top of the costula. Chela of the female with subequal digits, the fixed one with quite vestigial teeth on about half the dentarial margin, five or four in number; movable digit almost similar but with the teeth more conspicuous. Epigynum

rectangular or more or less trapeziform, longer than broad, scarcely curved in front, with anterior margin very finely serrulate, the whole of its integument distinctly roughened with lines of punctures. Sternum with punctured integument, and further, on each side with four distinct little areas picked out with lines of punctures; truncate behind almost in a straight line. Anal shield subcircular, small, furnished behind the anus with a rather long spiniform bristle. Legs provided with short subspiniform bristles.

Coleoprate nymph almost like the female but more villose and without any genital shield, with body more elongated, acute behind, distinctly shouldered, in colour less deeply tawny. Chelæ stronger than those of the female.

Male up to $750\ \mu$ in length; $480\ \mu$ in breadth.

Female up to $800\ \mu$ in length; $530\ \mu$ in breadth.

Coleoprate nymph up to $720\ \mu$ in length; $420\ \mu$ in breadth.

Habitat.—On the sea-shore under seaweed; quite frequent in France, Spain (and in Britain?).

FAMILY BDELLIDÆ (SNOUTED MITES).

Two species occur commonly on the shore at Millport. One of these, *Molgus littoralis* (L.), was recorded by King and Russell (1909) in a paper read before this Society, and specimens were then exhibited.¹ The other appears to be *Bdella longicornis* (L. 1758), Sig Thor, 1902. The reason for the double authority given is that Linnæus seems to have applied the same name to two different species, the one in his *Systema Naturæ* (1758), the other in his *Fauna Suecica*.

Molgus littoralis (L.).

= *Acarus littoralis*, L., *Systema Naturæ*, 1758.

= *Bdella basteri*, Johnston, *Acarides of Berwickshire*, Trans. Berwickshire Naturalists' Field Club, vol. ii. (1847), p. 221.

= *B. marina*, Packard, *Amer. Naturalist*, 1884.

= *B. littoralis* (L.), I. Trägårdh, 1902; etc.

This is a large scarlet mite found running over stones or amongst dry and decayed seaweed, for the most part above high-water mark, but at low water travelling down into the tidal region amongst the drying stones.

It is, according to Sig Thor (1902), the largest species of Bdellid known, reaching a length of from 2.5 to 3.5 mm.

None of the Millport specimens so far examined exceeded 2.5 mm. Its characteristic features are the presence of several bristles on the mandible (Fig. 8, MDB.), and the cylindrical form of the fifth joint of the palp (PLP. 5) which ends in a number of bristles of almost equal size.

Trägårdh (1902), in summing up what is known of the habits of littoral

¹ Mr Wm. Evans, F.R.S.E., has taken this species in the Forth Area since 1906.

Bdellids, quotes Trouessart as stating that this species feeds upon Collembola. He is not able to confirm this from his own observations, but adds that he has found *Bdella* sucking the larvæ of *Chironomus* sp. and attacking small flies; it also wanders over the surface of small accumulations of water and sucks the bodies of flies which have failed to emerge successfully from pupation.

The mites of this species collected at Millport have been supplied repeatedly with Collembola (*Anurida maritima* and *Isotoma maritima*), when kept in confinement, but, so far, have not been observed to feed upon them. The writer has seen the feeding of *Molgus littoralis* only once. This was upon the shore, and the food was a small living Dipteron, apparently the Borborid *Limosina zosterae*.

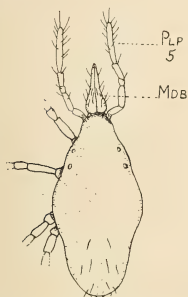


FIG. 8. *Molgus littoralis*.

Dorsal view, showing mandibles, MDB.,
and palp, PLP.

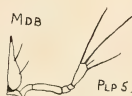


FIG. 9. *Bdella longicornis*.

Outline of right mandible
and palp, dorsal view. Fifth
segment of palp, PLP. 5.

The other species of Bdellid common on the shore of Millport is a mite of smaller size and of a brighter scarlet colour than the last. It is more gregarious in its habits, and is found both under dry seaweed and between the laminae of the fissile sandstone rocks. In both situations it is commonly associated with the Collembolan *Anurida maritima*, which probably forms its food, though the feeding has not been observed. In the autumn it has been observed to spin a silken tent, open at the top, in which apparently it prepares to spend the winter. The tent, with one or more mites inside, is found in the fissures of the sandstone.

This species is further distinguished from the last by the presence of only two bristles on each of the mandibles, and by the fact that the fifth joint of the palp (Fig. 9, PLP. 5) is expanded so that it is broader at its extremity

than at its base. Moreover this extremity bears two bristles much longer than the others of the segment. The species would therefore appear to be

Bdella longicornis (L. 1758), Sig Thor, 1902.

= *Scirus vulgaris*, Hermann (see Sig Thor, 1904).

= *B. rubra*, Latreille.

= *B. borealis*, L. Koch and Neuman, 1883.

= *B. vulgaris*, C. Canestrini, Prospetto dell' Acarofauna Italiana (1886).

= *B. decipiens*, I. Trägårdh, 1902.

For other synonyms see Sig Thor, 1904.

For this species Sig Thor gives the following note:—

Locality.—Abundant, especially littoral, seldom in grass, under stones, under pieces of wood, etc. Norway, Siberia, Nova Zembla, Spitzbergen, Behring Is., Jan Mayen, Greenland, Sweden (*r*), England, France, Germany, Austria, Switzerland, Italy, America.

The species is evidently of wide distribution and not exclusively littoral. *Molgus littoralis*, on the other hand, is stated by Sig Thor (1904) to be only littoral.

In conclusion, the writer offers the above notes mainly as of personal observations of some details of the habits and behaviour of four species of littoral mites to which he has given some study. These mites belong to families of predaceous, terrestrial Acarina, no doubt attracted to the shore by the special abundance of food material it offers. This abundance of food probably has direct causal relation to the large size attained by two of the species (*Eugamasus immanis* and *Molgus littoralis*).

Halolaelaps glabriusculus shows peculiar adaptation to a semi-aquatic existence in its habit of availing itself of the shelter and the limited air supply of rock crevices and of alga roots. In this way it adapts itself to the tidal rhythm.

SUMMARY.

In regard to the species mentioned, the principal points of interest noted above are as follows:—

Eugamasus immanis,

- (1) Method of feeding.
- (2) Method of cleaning appendages and body.
- (3) Mode of coition, and particularly the clasping function of the "stridulatory processes" of the second leg of the male.
- (4) Number of eggs laid.
- (5) Hatching.

Halolaelaps glabriusculus.

- (1) Occurrence.
- (2) Relation to submergence.

Molgus littoralis.

(1) Occurrence.

(2) Food.

Bdella longicornis.

(1) Occurrence.

(2) Tent making.

The tent-making habits of a littoral species of *Bdella* have been observed independently by Mr T. J. Evans of Sheffield University, though, as far as the writer is aware, no reference to them has been published.

There is much scope for further observation upon the life and habits of the littoral Acarina.

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XVIII.—On Some Carboniferous Arthropods, with Description of a New Genus of Myriapod. By B. N. Peach, LL.D., F.R.S.

(With Plate.)

(Read 24th March 1913. MS. received 15th December 1913.)

IN the spring of 1911, Dr Shand, who was then in charge of the Geological Department of the Royal Scottish Museum, Edinburgh, afforded me the privilege of examining some fossil Arthropod remains recently acquired for the Museum by exchange with Mr J. S. Neil, of Wolverhampton. Among them there is a very interesting suite of fossil Arthropods from the Coal Measures of Staffordshire, mostly preserved in clay-ironstone nodules, of which the following table gives a list:—

XYPHOSURA.

Belinurus lunatus, Martin, olim *B. bellulus*, König.

Prestwichia birtwelli, H. Woodward.

„ *dancæ*, Meek and Worthen.

Cyclus johnsoni, H. Woodward.

ARACHNIDA.

Anthracomartus hindi, Pocock.

CRUSTACEA.

Palæocaris sp. aff. *typus*, Meek and Worthen.

Pygocephalus cooperi, Huxley.

Anthracophausia sp.

MYRIAPODA.

Palæosphærotherium walcotti, sp. nov.

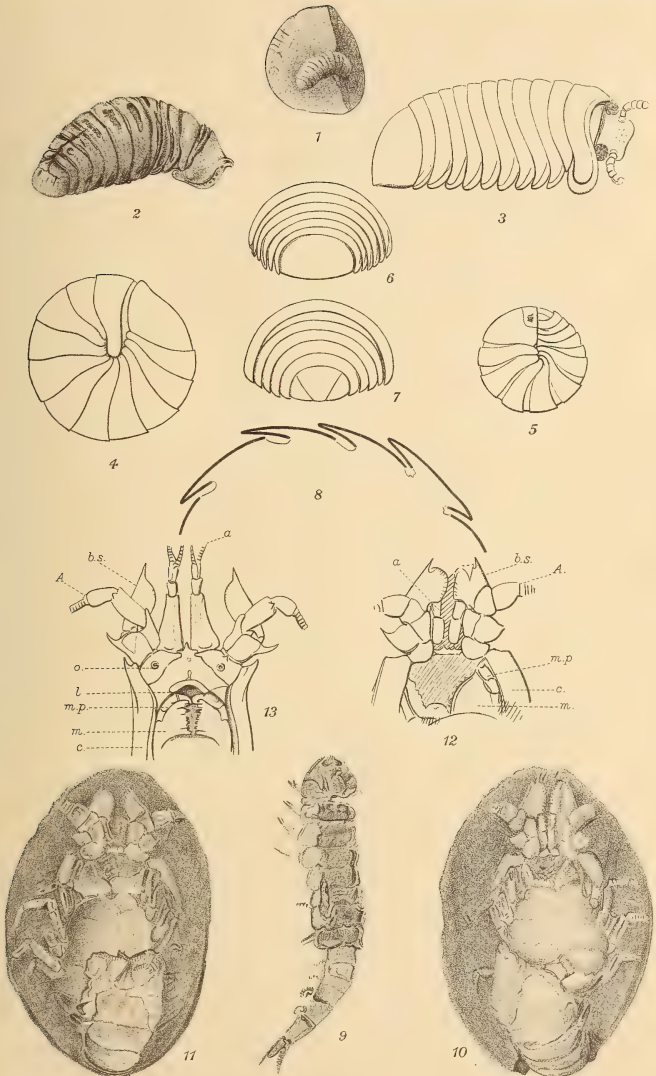
INSECTA.

Blattoidea sp. (abdomen of).

Aedæphasma anglica, Scudder.

Wings of types of undetermined Protorthopterid
and Palæorthopterid.

The main object of this paper is to describe a small specimen of rolling onisciform chilognathous Myriapod contained in the collection, which carries the history of this group back to Carboniferous time. Remarks will also be offered regarding some of the Crustacea in the collection which show points



not as yet illustrated. For the privilege of describing these interesting fossils I am much indebted to Mr W. F. P. M'Lintock, who is at present the custodian of the collection, more especially to Sir Carlow Martin, the Director of the Royal Scottish Museum, for his consent to their being described by me, and also to Dr James Ritchie for access to specimens of recent rolling Myriapods and Crustacea.

MYRIAPODA.

Sub-Class CHILOGNATHA.

Tribe ONISCIFORMÆ.

Palæosphærotherium,¹ gen. nov.

Description of Genus.—Rolling Myriapods with tergites similar to *Sphærotherium*, but differing from it in having fourteen instead of thirteen tergites.

Palæosphærotherium walcotti,² spec. nov. [Pl. IV. Figs. 1, 2.]

Preliminary Remarks.—The genus and species are based upon a single specimen preserved in the round within a clay-ironstone nodule. The dorsal and dorso-lateral view of only thirteen tergites is exposed, the head and the first tergite having evidently been displaced before the entombing of the remains.

The thirteen tergites preserved are mostly in natural relation to each other, though they have been somewhat obliquely compressed and distorted. The anterior portion of the specimen, back to the eighth dorsite, is partially rolled and slightly bent towards the right, and some of the tergites are partially and irregularly telescoped into each other.

Description of Species.—The specimen measures, in a straight line, about 14 mm., but considerably more along the curve of the back. The body is broadest and deepest about the eighth tergite whence it tapers gently forward and more rapidly and increasingly backwards. The test is plain and unevenly pitted with small punctures, but otherwise unornamented.

1st Tergite.—This tergite has not been observed. Judging from the arching and the nature of the anterior margin of the second tergite the first must have been small, and must have rolled backwards beneath the second as in the modern onisciform chilognaths.

2nd Tergite.—The second or nuchal tergite, the foremost one preserved,

¹ The name is intended to show the near relationship of this Palæozoic animal to the recent *Sphærotherium*.

² Named in honour of Dr Chas. D. Walcott, of the Smithsonian Institute, Washington, formerly Director of the U. S. Geological Survey, who has brought to light so many early Palæozoic Arthropods.

is large and measures about one-sixth of the whole length of the specimen. It is deeply arched, much narrower in front than behind, while its large side lappets extend backwards behind the main body of the tergite itself, and even to beyond those of the succeeding tergite. The anterior and antero-lateral margin is somewhat thickened, and followed immediately behind by a comparatively wide shallow groove which is continued into the side lappets. Behind the groove the body of the tergite becomes suddenly swollen, and rises into a rounded boss at the base of the side lappet. The posterior margin, extending between the bases of the side lappets, is simply a sharp doubling back of the test to form the articular surface under which the anterior part of the succeeding segment rolled. Larger pores than those found on the rest of the test can be traced along the shallow groove bordering the front part of the tergite.

3rd Tergite.—This tergite, which in the specimen is somewhat telescoped beneath the former one, measures only about a twenty-fourth of the whole length of the specimen. It tapers downwards, and only reaches down to about the base of the side lappets of the second tergite under which it rolls, while posteriorly it is sharply bent inwards and forwards to form the articulation under which the succeeding tergite folds in turn.

4th Tergite.—This tergite is in most respects similar to its predecessor. It is slightly wider than it and reaches farther down the sides and bears small side lappets which appear to be bevelled in front, though, owing to a slight bend of the body of the specimen, this part is concealed by the backward extending side lappets of the nuchal tergite. The nature and arrangement of its articulations with adjoining tergites are like those of its immediate predecessor.

5th to 8th Tergite.—These tergites are all similar to each other in most respects, except that they gradually increase in length and depth. The length of the eighth tergite is about one-ninth of the whole specimen. The articulations with each other are identical with those of the fourth tergite, while the side lappets are each bevelled off in front to allow of rolling.

9th to 13th Tergite.—These tergites are precisely similar to those just described, only they rapidly decrease in size so that the length of the thirteenth is less than half that of the eighth.

14th Tergite.—The terminal tergite is simple and makes nearly the quarter of a hollow sphere, and is similar in all respects to the terminal one in recent rolling Millipedes, except that it is relatively smaller. In the present specimen it measures along the curve of the back only about one-sixth of the whole length of the specimen, whereas in *Spharotherium* it measures nearly one-third of the length of corresponding parts.

General Remarks.—To illustrate the close affinity of the remains above described to recent forms, Pl. iv. fig. 3 shows a drawing of *Sphærotherium grossum*, Koch, the type species, natural size, after Koch, a form that inhabits South Africa. Fig. 4 is drawn, also natural size, from a specimen of a large species of *Sphærotherium* from Madagascar, now in the Royal Scottish Museum, to show the method of rolling in these onisciform Millipedes. The terminal tergite completely hides the head and the first tergite under its hollow arch, and overlaps the anterior margin of the second tergite to come to rest against the swollen body of that tergite. It may also be seen that the turgid part of the second tergite, where it is carried down to the side lappets, forms a central knob round which the following segments arrange themselves, somewhat like the spokes of a wheel round the nave. The use of the knob seen on this part of the fossil form (Fig. 2) is thus explainable. The relative arrangement of the tergites and the side lappets in the succeeding tergites is similar in the fossil to that of the recent animal, thus leaving no doubt that these ancient creatures were adapted for rolling.

To mark the contrast between these Millipedes and an Isopod Crustacean, which has adopted the same tactics of rolling for the protection of its more delicate organs, Fig. 5 has been drawn (magnified about three diameters) from a specimen of *Armadillidium vulgare*, or what is commonly known in Scotland as "the pill slater." The crustacean nature of the rolled animal is at once apparent. The sclerite bearing the eyes is exposed partially enveloped within that of the first free trunk segment, the two together simulating the second or nuchal tergite in *Sphærotherium* and playing very much the same role as it. These are followed by the sclerites of six other trunk segments. Then comes a sudden change between the trunk and tail sclerites; five of the latter only are exposed, the first being either entirely hidden or aborted, and the second partially overlapped by the pleura or epimera of the last trunk segment. The body ends in three plates which simulate the end tergite of the Millepedes, but which is in fact a tail fan made up of a central telson flanked by the uropods of the sixth tail segment. Figs. 6 and 7 are diagrammatic representations of these tails seen end on. Fig. 6, the single plate, is that of a rolling Millepede like the fossil one, while Fig. 7 is that of *Armadillidium*.

Though the method of rolling of *Armadillidium* is somewhat similar to that of the Millepedes, there is a considerable difference. There is no overlap of the epimera of the tail, or of the margin of the tail fan, over that of the opposing margins of the two segments which simulate the nuchal plate of the Millepede, so that, although the delicate antennular and antennary parts are covered up, the eyes are left unprotected. The epimera of the trunk

segments overlap each other from in front backwards, affording a firm hinge so that the tail may fit accurately against the edges of the two anterior sclerites.

Locality.—The exact locality is not given, but the attached labels denote that the specimen is from the South Staffordshire Coalfield.

Horizon.—Coal Measures.

Type Specimen.—Geological Collection, Royal Scottish Museum.

CRUSTACEA.

Division **SYNCARIDA**, Packard.

Sub-Order **ANASPIDACEA**, Calman.

Genus **Palæocaris**, Meek and Worthen, 1868.

Palæocaris sp. [Pl. IV. Fig. 9.]

Among the Crustacean remains preserved in the ironstone nodules of the Gubbins Collection are those of a form which belongs to the group Anaspidacea of Calman, but which is not in a fit condition for accurate description. It consists of a form with a short anterior segment followed by seven distinct dorsal sclerites representing the free trunk or thoracic segments, and these again in turn by six abdominal segments, and ending in a tail fan composed of a short telson flanked on each side by the uropods of the sixth tail segment.

The first dorsal sclerite which, though it does not extend backwards over the seven free trunk segments, is the homologue of the carapace in the macrurous decapods. It is of the conventional heart shape, with the pointed end turned forwards. There is a distinct rostrum, flanked at its base by hollows suggesting that they had accommodated stalked eyes. The carapace is divided into three distinct areas by deep sulci, which begin near the thickened lateral margins about half-way from front to back and pass inwards and backwards in a curved line to the posterior margin, dividing that line into three nearly equal parts. The central area is much the largest and is strongly embossed. No appendages have been preserved in relation to this part of the specimen.

The seven trunk or thoracic segments are nearly equal in size, and are divided into a central dorsal part and side lobes or pleura by lines continued backwards from the sulci on the first sclerite or carapace. Remains of five well-jointed robust limbs are seen to emerge from beneath the pleura of the left side of four of the more anterior free trunk segments, and from the last of the trunk segments. From their nature these must represent endopodites. A many-jointed lash, which must represent an exopodite of a

thoracic limb, is seen to project beyond the pleura of the fifth and sixth trunk segments.

Behind the last thoracic segments the body suddenly narrows, the tail segments becoming longer and narrower as they are followed backwards, and very slender near the insertion of the telson. The pleura of these segments are inconspicuous, and not nearly so well developed as those of the thoracic segments. Three of these segments still bear many-jointed pleopods, both branches of which are preserved, one of these limbs on the fourth tail segment. The tail fan is made up of a short sub-quadrate telson, flanked by much longer knife-blade-like uropods, representing the exopodites of the limbs of the sixth segment. The endopodites are not observable, being either small and delicate or not present. The whole arrangement of the tail fan is similar to that found in the Mysids.

These remains have been provisionally placed in Meek and Worthen's genus *Palæocaris*, but owing to the state of preservation it would be injudicious to give to them a specific name.

Locality.—South Staffordshire Coalfield.

Horizon.—Coal Measures.

Division **PERACARIDA**, Packard, 1879.

Family **LOPHOGASTRIDÆ**, Sars.

Genus **Pygocephalus**, Huxley, 1857.

Pygocephalus cooperi, Huxley, Quart. Jour. Geol. Soc., 1857. [Pl. IV. Figs. 10-12.]

In his paper published in the *Geological Magazine* for 1907, Dr Henry Woodward figures two specimens of *P. cooperi* showing remains of two females with the breeding lamellæ in place,¹ thus proving that these forms had their proper place among the Mysids, as had already been suggested by Huxley as far back as 1857.²

In the Gubbins Collection is a third specimen of a female with breeding lamellæ in situ, which exhibits points not hitherto described. Fig. 10 shows the ventral view in relief, the dorsal portions being embedded in the iron-stone nodules, all except the tail, which is characteristically folded over the hinder part of the thorax. Fig. 11 is the counterpart of the same specimen in intaglio. The chief points shown in the present specimen is the remarkable state of preservation of the antennular and antennary systems, and the mandible with its palp. The arrangements of these parts is quite caridean. For the purpose of illustrating this point Figs. 12 and 13 have been drawn.

¹ *Geol. Mag.*, vol. iv., new ser., pp. 400-407, pl. xviii., 1907.

² *Quart. Journ. Geol. Soc.*, vol. xiii. pp. 363-369, pl. xiii.

Fig. 12 is the outline of the parts shown in the fossil, multiplied one and a half diameters, to compare with Fig. 13 and outline of the corresponding parts in the present-day *Nephrops norvegicus*. Search was made for the openings of the green glands on the bases of the antennæ, but without result.

The chief characteristic of the specimen is the wide marsupium, made up of at least six pairs of broad plates or breeding lamellæ overlapping along the mid-line and completely concealing the terminal plates. The marsupium is almost identical with that of the recent *Gnathophausia* as figured by Sars in his "Challenger" Report.¹ The specimen also affords additional information regarding the tail and the tail fan, and shows that the telson was furnished with a terminal lobe as in the Carboniferous *Anthrapalæmon* and the recent *Gnathophausia*.

Locality.—South Staffordshire Coalfield.

Horizon.—Coal Measures.

EXPLANATION OF PLATE.

- Fig. 1. *Palæosphærotherium walcotti*, sp. nov., type specimen, nat. size. Coal Measures, Staffordshire. Royal Scottish Museum, Edinburgh.
- „ 2. *Palæosphærotherium walcotti*. Same as Fig. 1; magnified 3 diameters.
- „ 3. *Sphærotherium grossum*, Koch, nat. size; outline drawing after Koch.
- „ 4. *Sphærotherium* sp., nat. size; to show method of rolling of Millipede. Drawn from a large recent species from Madagascar. Royal Scottish Museum.
- „ 5. *Armadillidium vulgare*, Latr., magnified about 3 diameters, to show method of rolling of Isopod Crustacean.
- „ 6. *Palæosphærotherium walcotti*, magnified diagrammatic view from behind, to compare with Fig. 7.
- „ 7. *Armadillidium vulgare*, corresponding view from behind, to compare with Fig. 6.
- „ 8. Diagrammatic section, dorsites 1-6, along mid-line of rolling Millipede, to show mode of articulation to allow of rolling.
- „ 9. *Palæocaris* sp., magnified 2 diameters. Coal Measures, Staffordshire. Royal Scottish Museum.
- „ 10. *Pygocephalus cooperi*, Huxley. Embedded in ironstone nodule. Ventral view, nat. size. Coal Measures, Staffordshire. Royal Scottish Museum.
- „ 11. *Pygocephalus cooperi*, Huxley. Counterpart of Fig. 10.
- „ 12. *Pygocephalus cooperi*, Huxley. Part of Fig. 10, magnified $1\frac{1}{2}$ diameters, to compare with Fig. 13. Cross-hatching denotes embedding matrix. Lettering as in Fig. 13.
- „ 13. *Nephrops norvegicus* (Linn.), nat. size. Drawing of ventral view of anterior parts, to compare with Fig. 12. Recent, from North Sea.

a, Antennules; *A*, Antennæ; *bs*, Basal Scales of Antennæ; *o*, Opening of "Green" Gland; *m*, Mandibles; *mp*, Mandibular Palp; *c*, Carapace.

¹ G. O. Sars, "Report on the Schizopoda," *Voyage of H.M.S. Challenger*, pls. iv., v. and vi., 1873-1876.

XIX.—An Account of the Bird-lice of the Genus *Docophorus* (Mallophaga) found on British Auks. By James Waterston, B.D., B.Sc.

(MS. received 8th January 1914. Read 26th January 1914.)

A. HOSTS; COLLECTING; NORMAL PARASITISM; "STRAGGLING."

EXCLUDING the extinct *Alca impennis*, L., there are six species of Auk on the British list. One of these, however, *Uria bruennichi*, E. Sabine, is of extreme rarity in our waters. The present paper essays merely to define what species of *Docophorus* are normally to be found on the following—*Alca torda*, L., *Uria troile*, L., *Uria grylle*, L., *Mergulus alle*, L., and *Fratercula arctica*, L. For four years I have been well placed for examining these hosts, for in Shetland all are to be found in numbers at one season or another. Ollaberry lies on a bay off the west side of Yell Sound, some distance from the open sea. "Tysties," or Black Guillemots, are constantly with us; Little Auks come regularly towards the end of the year; Common Guillemots and Puffins are common at intervals; and only the Razorbill is infrequent in its appearances. During the period of investigation parasites have been taken or received by me from a sufficient number of the five host species to warrant the conclusions now put forward. Upwards of 1000 specimens of *Docophorus* from 44 hosts have been examined. Between 30 and 40 of the birds have been obtained locally. Most of the Guillemots, Razorbills, Little Auks and one of the Puffins have been found in a dying or dead condition after gales which, when prolonged, cause a heavy death roll among sea-birds. *Uria troile* is possibly the commonest victim one comes across, but I have never seen *U. grylle* succumb to stress of weather. To correspondents and others who have assisted in procuring material, my best thanks are due. These services are elsewhere acknowledged in detail. I also desire to thank the Carnegie Trustees for a grant in aid of the present research.

Some notes on collecting, etc., may be offered. Each host has been examined as soon after death as possible, and all parasites picked up with fine forceps and placed in preservative. For general purposes the strongest industrial methylated spirit (up to 95 %) has been employed, as my experience of the 70 % usually advocated for ectoparasites has been unsatisfactory. In the weaker solution discoloration and maceration sooner or later set in, presumably owing to the weakening of the spirit by dilution with the juices of the parasites, and through evaporation. This is no great disadvantage with males which, as a rule, may be identified in any state by

the genitalia, but it is an advantage to keep females in as lifelike a condition as possible. The only examples liable to be affected by the strong spirit are those which have newly moulted. Specimens intended for mounting in balsam may be put in a mixture of 3 parts of absolute alcohol to 1 part of glacial acetic acid. So treated they die with legs and other appendages extended, and a good deal of the internal fat is removed at the same time, so that a less prolonged treatment with caustic is required before mounting.

In collecting Mallophaga a diary should be kept of hosts examined, with under each entry a rough note of the genera and species found. After a time the insects may be separated and each lot labelled and card-indexed.

Before examining a bird it is well to plug up shot wounds (where Mallophaga, especially Liotheids, migrate and frequently get clogged up in blood), the nostrils, throat, and even the anus. Such precautions are very necessary in the case of the Auks. The oleaginous contents of their stomachs exuding, quickly soil the plumage in the region where the search for parasites is most likely to be rewarded. Owing to their short stiff feathers Auks may be thoroughly examined without recourse to the hand plucking so often necessary. If one's search is prolonged, the great bulk of the parasites present may be gathered from round the eyes and below the bill where, given time, they obligingly congregate.

During examination the birds should be isolated on white sheets, or kept in cotton bags. All hosts indeed should be separately packed from the first, and never allowed to lie indiscriminately in the game-bag. The aim of such precautions is to avoid misleading records of "straggling." In this respect the diary may prove a useful check on the card-index.

Mallophaga can be kept either in alcohol or as slides. No card-mounted specimen should be tolerated in a collection. Each lot of a species may be placed, fully labelled, in a tube $1\frac{1}{4}'' \times \frac{3}{16}''$ or $\times \frac{1}{4}''$ as may be required. Each little tube is plugged with cotton wool, and 8-10 may be placed in a squat tube $1\frac{7}{8}'' \times \frac{7}{8}''$. These larger tubes may be housed, to the number of 8, in a glass-stoppered jar $3\frac{1}{4}'' \times 3\frac{1}{8}''$. Such sizes I have found most practically useful. Thus a jar of the collection will store from 60-80 lots of parasites, any one of which may be expeditiously inspected. The bugbear of corks is avoided, and the alcohol may be renewed in one operation. The system is also cheap, as 1000 or more insects may be housed permanently for an outlay of about 2s. 6d. As to the method of recording—the time-honoured path has been followed and stress laid on locality. But in reality the exact locality (though not the nature of it) is of secondary importance in elucidating the many problems connected with the distribution of these parasites. *The area of distribution is here no longer a geographical one, but primarily an individual*

organism and secondarily a species or group of species. As Prof. Kellogg in a recent brilliant resumé points out: "Each host individual is in a way a small island biologically considered, with its inhabitants more or less nearly completely isolated from the inhabitants of other islands" (V. L. Kellogg, *The American Naturalist*, vol. xlvii., March 1913, p. 134), and the comparison is just if we add that these islands have an almost unchanging climate, wander about in space and occasionally come into contact, and finally are subject to periodic cataclysms which, if they do not destroy the inhabitants directly, at least set very many adrift to shift for themselves. We want to know what is the average population of these "islands"? what is native in it? what and how derived is any alien element present? How far, again, does the population fluctuate seasonally? How far do individual birds carry what may be termed family strains of a particular species of parasite? and to what extent does the mixing of hosts lend towards uniformity in the characters of their parasites? What is the age of a species of *Docophorus*?—and so on. It is evident that an ideal record would comprise very many items. It would include a census of the parasites (species and numbers) found; and an exact analysis of the stages (egg; larva or immature; imago) represented; the state of the hosts' plumage, age and date of capture; a note on the hosts' habits and state of health, etc. It is only after much laborious spadework of the above description that anything may be expected of this field. But chiefly there is need at present of a more accurate definition of names, especially of the species of older authors. The host distribution of some of the commonest forms requires clearer determination. It is in the latter respect that it is hoped this contribution may prove of service to workers.

Some notes, relevant only to the present inquiry, may be given on the species of *Docophorus* which have been described or recorded from Auks.

Nitzsch named the parasite of *Alca torda*, *D. celedoxus*. This species, mentioned by Burmeister in his "Handbuch" (1839), was again recorded by Denny (1842) from *Alca torda*, *Uria troile*, and *Fratercula arctica*. At the same time the English author described three new species—*D. platygaster* from *Uria troile*, *D. megacephalus* from *Uria grylle*, and *D. merguli* from *Mergulus alle*. Giebel (1874) adds little beyond describing more accurately than Denny the characters of Nitzsch's species, of which the types were before him. Piaget (1880), who remarks of *D. celedoxus*, "Sur une *Alca torda*, une *Uria troile* et selon Giebel sur une *Fratercula arctica*," gives a good but very general account, and an excellent figure of the head of the species (he figures also the female genital mark), but his measurements seem to be taken from a small example. Lastly, in 1896, Kellogg described two new species, viz. *D. calvus* from a variety of the Common Guillemot, and

D. acutipectus from a Fraterculine host. He also with B. Chapman (1899) introduced *D. procax* from a close ally of *Uria grylle*. All three species were secured on Pacific hosts. Of these species (to which fuller references are given below) we may take first Denny's creations. His *D. megacephalus* and *D. merguli*, though neither was recorded for seventy years after their publication, are, I believe, perfectly valid and distinct species.

As to *D. platygaster*, I am inclined to think that it does not belong to the group of *Docophorus* now under review. I had hoped it might turn out to be the species commonly found on *Uria troile*, but my examination of the types failed to bring this conviction. I speak with hesitation, as at the time of my visit the Denny collection was mounted on cards and not really in a condition for critical working.

It is when one attempts to name material from Common Guillemot, Razorbill and Puffin that difficulty may be felt. Three species in all infest these hosts. A study of the male genitalia made this beyond dispute. But it was only through the kindness of Professor Kellogg, who sent the writer a male and female of his *D. calvus*, that the identity of the three species could be made reasonably sure. What I believe to be *D. acutipectus*, Kell., is not hard to distinguish from *D. celedoxus* by a number of evident characters. But the differences between *D. celedoxus* and *D. calvus* are somewhat critical, and might easily be considered to be only of varietal value if one had not examined the genitalia. For this reason, although *D. celedoxus* occurs undoubtedly on *U. troile*, *A. torda* and *F. arctica*, it is so rare on the first named that records of the parasite from all three hosts should be received with reserve. So far as I am aware, the only recent European writer who has given expression to this feeling of hesitation is Eric Mjöberg ("Studien über Mallophagen und Anopluren," *Arkiv. för Zoologi*, Band 6, No. 13, p. 132, 1910), who remarks under *D. celedoxus*, N.: "Von der Art liegen mir mehrere exemplare von sowohl *Uria triole* (*sic*), *Uria grylle* und *Mormon arcticus* vor (Mus. Gbg. Roth. Videll, *ipse*). Zwar stimmen die Ausgaben *Piaget's* nicht völlig mit den mir vorliegenden exemplaren ein; so ist *Z. B. Clypeus* nach vorn bei weitem nicht so tief ausgerandet und auch die Genitalflecke beim ♀ nicht völlig ähnlich, ich führe sie aber zu dieser Art, der sie sich jedenfalls am nächsten anschliessen." Mjöberg, from these remarks, appears to have had before him either *D. celedoxus* and *D. calvus*, or *D. celedoxus* and *D. megacephalus* female—or possibly all three.

To Messrs Bagnall and Hall belongs the credit of separating an unfamiliar *Docophorus* from among some examples of *D. celedoxus* collected on Puffin (*F. arctica*), Farne Islands, Northumberland (*Journ. Econ. Biol.*, vol.

vii., No. 1, p. 9, Feb. 1912). The specimens so separated were determined by Prof. Kellogg as *D. acutipectus*. In October of the same year Mr Wm. Evans published, in his "List of Mallophaga taken in the Forth Area" (*Proc. Roy. Phys. Soc. Edin.*, vol. xviii., No. 4, p. 270, 1912), records of *D. celedoxus* (from *U. troile*, *A. torda* and *F. arctica*), and *D. merguli* (from *M. alle*); while in *Ent. Mo. Mag.*, p. 113, 1913, the writer drew attention to Denny's neglected *D. megacephalus*.

Assuming, as is done here, that *D. platygaster*, D., is not the normal parasite of *U. troile*, the records of *D. calvus* now given form an addition to the British, or for that matter to the European, list. A word of caution, however, as to the meaning of such "additions" is necessary. We are not signalling the introduction of an American element into our fauna in adding *D. acutipectus* and *D. calvus* to our lists. The case is not parallel say to the discovery of an American bird in Britain, or to the recent occurrences of the Plague Flea (*Xenopsylla cheopis*) in Portsmouth and London. We are simply recognising in Britain insects first described from American hosts. The five species of *Docophori* enumerated below might, I believe, have been collected in this country ever since there were Auks on our waters with *Docophori* upon them.

In the following list the symbol \odot = immature. I have given the names of all friends who have sent or secured hosts for this investigation. Where "leg." occurs after a name, the correspondent sent the parasites and vouched for the host. In other cases, the writer is personally responsible.

DOCOPHORUS ACUTIPECTUS, Kellogg (1896).

Docophorus acutipectus, V. L. Kellogg, New Mallophaga, pt. 1, p. 84, pl. iii. fig. 4 (1896).

From *Fratercula arctica*.—(1) Ollaberry, 5:vi:12, 4 ♂, 9 ♀, \odot : 17:v:13, 2 ♀: June 1913, 2 ♂, 2 ♀, with *D. calvus*, Kell. (2) Gluss Voe, 20:i:13, 5 ♂, 6 ♀, \odot , with *D. celedoxus*, N. (3) Off Little Roe, Yell Sound, 29:v:11, ♂, 2 ♀: 10:xi:13, 6 ♂, 7 ♀, 3 \odot , with *D. calvus*, Kell., and *D. celedoxus*, N.

DOCOPHORUS CALVUS, Kellogg (1896).

Docophorus calvus, V. L. Kellogg, New Mallophaga, pt. 1, p. 79, pl. iii. fig. 1 (1896).

From *Uria troile* (ringed form).—Dunbar, 1:ii:10, 9 ♂, 6 ♀, \odot , per H. M'Kay, leg., bird shot by Mr Inglis.

From *Uria troile* (typical form).—(1) Ollaberry, 8:xii:10, 15 ♂, 14 ♀, 4 \odot : 29:iv:11, 8 ♂, 10 ♀, 5 \odot , with *D. celedoxus*, N.: xii:12, 4 ♂, 13 ♀: 19:iii:13, 17 ♂, 27 ♀, \odot . (2) Gluss Voe, 22:iii:11, 18 ♂, 28 ♀, 5 \odot : 22:ii:12, 22 ♂, 13 ♀, 5 \odot , with *D. celedoxus*, N.: 2:iii:12, 11 ♂, 19 ♀,

4 ☉ : 7 : x : 12, 5 ♂, 8 ♀, 7 ☉. (3) Rönas Voe, 6 : iii : 11, 13 ♂, 30 ♀, 11 ☉, R. Jamieson : 23 : iii : 11, 3 ♂, 2 ♀, with *D. merguli*, D.

From *Fratercula arctica*.—(1) Ollaberry, June 1913, ♂ with *D. acutipectus*, Kell. (2) Off Little Roe, 10 : xi : 13, 2 ♀, with *D. acutipectus*, Kell., and *D. celedoxus*, N.

From *Larus (Rissa) tridactyla*.—Gluss Voe, 13 : iii : 11, ♀.

DOCOPHORUS CELEDOXUS,¹ Nitzsch (in MS. before 1839).

Docophorus celedoxus, Nitzsch, in Giebel Ins. Epiz., p. 117, pl. xi. figs. 1, 16 (1874).

From *Alca torda*.—(1) Aberdour, Fifeshire, 3 : ii : 13, ♀, J. Skinner, leg. (2) Ollaberry, 26 : x : 10, 9 ♂, 27 ♀, 6 ☉, with *D. megacephalus*, D. : 5 : xii : 11, 3 ♂, 10 ♀. (3) Gluss Voe, 28 : xii : 12, 8 ♂, 11 ♀, ☉ : 30 : xii : 12, 10 ♂, 30 ♀, ☉. (4) Rönas Voe, 20 : iii : 11, 20 ♂, 20 ♀.

From *Fratercula arctica*.—(1) Gluss Voe, 20 : i : 13, 4 ♂, 4 ♀, ☉, with *D. acutipectus*, Kell. (2) Off Little Roe, 10 : xi : 13, ♀, with *D. acutipectus*, Kell., and *D. calvus*, Kell.

From *Uria troile*, in company with *D. calvus*, Kell.—(1) Ollaberry, 29 : iv : 11, ♂ and ♀. (2) Gluss Voe, 22 : ii : 12, 6 ♀.

DOCOPHORUS MEGACEPHALUS, Denny (1842).

Docophorus megacephalus, Denny, Monogr. Anopl. Brit., p. 86, pl. v. fig. 5 (1842).

„ *procar*, V. L. Kellogg and B. Chapman, New Mallophaga, pt. iii., p. 54, pl. v. fig. 1 (1899).

From *Uria grylle*.—(1) Ollaberry, 3 : viii : 10, 5 ♂, 10 ♀, 20 ☉. (2) Gluss Voe, 22 : ii : 12, 3 ♀, 3 ☉ : 30 : iii : 12, ♂, 4 ♀, 6 ☉ : 24 : ix : 12, 15 ♂, 30 ♀, 24 ☉ : 7 : x : 12, 5 ♂, 4 ♀, 7 ☉ : 30 : xii : 12, ♂, 4 ♀, ☉. (3) Gluss Point, 20 : vi : 10, 2 ♂, ♀, ☉ : 21 : viii : 11, 6 ♂, ♀, 2 ☉ : 7 : v : 12, 34 ♂, 17 ♀, 24 ☉. (4) Near Lamba Is., Yell Sound, 6 : ix : 10, 3 ♂, 3 ♀, 17 ☉ : 25 : ix : 12, 25 ♂, 25 ♀, 70 ☉.

From *Alca torda*, with *D. celedoxus*, N.—Ollaberry, 26 : x : 10, ♂.

DOCOPHORUS MERGULI, Denny (1842).

Docophorus merguli, Denny, Monogr. Anopl. Brit., p. 72, pl. iii. fig. 7 (1842).

From *Mergulus alle*.—(1) Nr. Loughton, Staffordshire, England, Feb. 1912, Hon. N. C. Rothschild, leg., 2 ♀. (2) Scampston Hall, Rillington, Yorkshire, England, 2 : ii : 12, Hon. N. C. Rothschild, leg., 5 ♂, 5 ♀. (3) Firth of Forth, 9 : i : 11, Miss Baxter, per H. M'Kay, leg., 2 ☉ : Granton, 29 : i : 12, J. F. Cormack, leg., 2 ♂, 2 ♀ : Kirkcaldy, Jan. 1913, J. Skinner, leg., ♂ : Largo, 16 : i : 13, J. Skinner, leg., 3 ♀ : (4) Ollaberry, 16 : xii : 11, H. Williamson, ♂, 3 ♀, 3 ☉ : 30 : xii : 11, Dr Lovett, ♂, ♀, 4 ☉. (5)

¹ *Celedoxus* does not appear in Nitzsch's list of *Docophorus* spp. (p. 290, *German's Magazin*, 1818). I have simply followed Giebel, Piaget and Kellogg in retaining Nitzsch's authorship.

Gluss Voe, 20:i:13, A. Williamson, 7 ♂, 11 ♀: Jan. 1913, 38 ♂. 34 ♀, 25 ☉.

From *Uria troile*, with *D. calvus*, Kell.—Rönaas Voe, 23:iii:11, ♀.

Besides the above five species I have a single ♀, *D. cordiceps*, P. (not uncommon on various species of Charadriidæ), taken with *D. merguli* on *M. alle*, Gluss Voe, 20:i:13. Mr H. M'Kay has also sent me a ♂ example of *D. icterodes*, N (attached to Anatidæ chiefly) from *A. torda*, Aberlady, 29:i:10 (Ritchie).

These auk *Docophori* represent two types—(a) *acutipectus*, *calvus* and *celedoxus*; (b) *megacephalus* and *merguli*. The above records enumerate 564 examples of class (a) from 23 hosts, and 526 examples of class (b) from 21 hosts. On such a basis it seems fair to compare the proportions of the sexes. It is interesting to note that in the first section the males aggregate about 40 % of the mature examples, in the second nearly 50 %, i.e. in the "*calvus*" group the females outnumber the males as 3:2, in the "*megacephalus*" group the sexes are approximately equally divided.

The number of Mallophaga to be expected on a host, as well as the regulating conditions of their occurrence, form an obscure subject. Of *Docophorus* alone, anything up to 50 specimens or rather over may be regarded as normal, and taking the concomitant *Nirmus* and *Menopon* into the reckoning, 100-120 may not be an excessive estimate of the mallophagous parasites of a bird before the moult. Many of the above records are exhaustive for the individuals to which they refer, but more than once hosts have been found covered with parasites, but unfortunately at times when a complete enumeration was impracticable. Young birds before the first moult appear to suffer most; next come those examples which float ashore to die. But after moulting, birds may be found as clean as the most fastidious small passerine.

Ill health and emaciation do not always mean a large mallophagous population. I have frequently noticed that where the tick (*Ixodes putus*, Cambr.) is present in force no Mallophaga can be found, though the presence of a few examples of *Ixodes* seems in no way deterrent. On 10:xi:13, a pair of young Puffins, evidently a late hatching, were secured in Yell Sound together. These birds were in extremely poor condition and much smaller than average birds of the year. One harboured *D. calvus*, *D. celedoxus* and *D. acutipectus*; the other provided no Mallophaga, but the head in front of the eyes was, a few hours after death, covered with a scum of mites.

The following table summarises the results of the records given above:—

	<i>Uria troile.</i>	<i>Alca torda.</i>	<i>Fratercula arctica.</i>	<i>Uria (Cepphus) grylle.</i>	<i>Mergulus alle.</i>	<i>Rissa tridactyla.</i>
	11 birds.	6 birds.	6 birds.	11 birds.	10 birds.	1 bird.
<i>D. acutipectus</i> , Kell.	...	...	¹ { $\times (6)$	...	...	...
<i>D. calvus</i> , Kell. .	$\left\{ \begin{array}{l} \times (11) \\ \times (2) \end{array} \right.$	...	¹ { $\times (2)$	...	...	$\times (8)$
<i>D. celedoxus</i> , N. .	$\left\{ \begin{array}{l} \times (2) \\ \times (1) (S) \end{array} \right.$	$\left\{ \begin{array}{l} \times (6) \\ \times (1) (S) \end{array} \right.$	$\times (2)$	...	...	Solitary ♀ with numerous examples of <i>D. larri</i> , D.
<i>D. megacephalus</i> , D.	$\times (1) (S)$	...	...	$\times (11)$...	
<i>D. merguli</i> , D. .	...	...	...	...	$\times (10)$	
<i>D. icterodes</i> , N.	...	$\times (1) (S)$	...	...	$\times (1) (S)$	
<i>D. cordiceps</i> , P.	...	...	...	...

A \times denotes the occurrence of *Docophorus* on bird sp. The number in brackets indicates how often the parasite has occurred on the host species.

The long brackets with their numbers show how often and how many species have occurred together on an individual host.

(S) = straggler.

Thus column one reads: "Of *Uria troile*, 11 birds have been examined and on all *D. calvus* has been taken. In two cases *D. calvus* has been found with *D. celedoxus*, and once with *D. merguli*. The last, however, seems a case of 'straggling.'"

1. From the above analysis, it will be seen that each of the five Auks found in British waters has a species of *Docophorus* peculiar to itself within that area.

2. It should not however be inferred that, apart from straggling, there is a constant connection between the parasite species and one host species, e.g. *D. acutipectus* and *F. arctica*, etc. *Docophorus* species as a rule attach themselves either to a group of birds, or to a genus, or to near relatives within the same genus; and the fact that we have five auk *Docophori* in Britain would indicate that the hosts represent as many genera. So far as it goes the evidence here is for the separation of *Cepphus* from *Uria*. Outside British waters the *Docophori* just recorded may be expected on closely allied species of the host genera. *D. calvus* was described from *Uria troile californica* (Bay of Monterey, California); *D. acutipectus* from *Ceratorhina monocerata* (Bay of Monterey, California); *D. procar*, K. and C. (which seems to me indistinguish-

¹ On one individual also *D. acutipectus* and *D. celedoxus* were found associated.

able from *D. megacephalus*, D.) from *Cephus columba* (Bay of Monterey, California). I have not, however, had an opportunity of examining *D. procax*.

3. While every host examined has yielded a peculiar species of *Docophorus*, "straggling" of an interesting kind is also exhibited.

D. icterodes on *A. torda* and *D. cordiceps* on *M. alle* are entirely accidental. The former may have come from some duck or allied waterfowl, the latter from a wader—probably *Streptilas interpres* or *Tringa maritima*.

More important are the occurrences of these *Docophori* on Auks other than that to which respectively each is specially attached. One feels the limitations of the category "straggler" here. It has to be used so comprehensively from cases of the most accidental nature to others in which environment and life habits play an intelligible part.

D. merguli on *U. troile* and *D. megacephalus* on *A. torda* are probably as unusual and casual as the two cases noted above. Yet it is not wonderful that such instances should occur in Shetland where, on many a day in January, after a gale one may see in some sheltered voe all five species of Auk within gunshot.

D. calvus on *Rissa tridactyla* is easily understood. The Kittiwake is of all our gulls the most marine in habitat. It is closely associated with *Alca*, *Uria* and *Fratercula* both at the breeding season and subsequently.

The constant mingling of Puffins, Common Guillemots and Razorbills—especially on the nesting ledges—is naturally reflected in the records of their respective *Docophori*. Thus *U. troile* has yielded *D. calvus* and *D. celodoxus*, while on *F. arctica*, *D. acutipectus* occurs as well. But it is noteworthy that *D. acutipectus* has been met with so far only on Puffin, and it is surprising that *D. calvus* has not occurred on Razorbill which nests side by side with Guillemot, so that sometimes the two species literally rub shoulders. Possibly a sufficient number of Razorbills has not been examined. The really striking feature of the occurrences of *D. calvus* and *D. celodoxus* is their constant attachment to one host—a fact which shows through any other "straggling" that may be noted. It is my impression that *D. celodoxus* has established itself on *F. arctica* as well as its regular host. But a good deal of collecting will be required before the status of *D. celodoxus* on *U. troile* or of *D. calvus* on *F. arctica* is intelligible. On *Uria grylle* only *D. megacephalus*, D., has occurred in my experience. More remarkable still, no other mallophagous species appears as a rule to infest this host. I have taken *Menopon* once on it, and on another occasion a solitary *Nirmus*, which is probably a straggler. However these facts may ultimately be explained, the absence of other auk *Docophori* on *U. grylle* is due probably to the

habits of the bird. It is an inshore feeder, breeds not on ledges but in holes, crevices, or under boulders, and, except under stress of weather, does not associate closely with other Auks. Possibly a similar explanation may hold of *M. alle*, which likewise has one *Docophorus* invariably present. The Little Auk, however, harbours a *Nirmus* and a *Menopon* as well.

D. merguli, D., and *D. megacephalus*, D., have important structural features in common, notwithstanding some superficial dissimilarity, and are somewhat apart from *D. acutipectus*, K., *D. calvus*, D., and *D. celedoxus*, N., which form a compact group. All five species may however be treated conveniently together, and this I hope to do in a later instalment dealing with the distinguishing features of the species and their known distribution in Britain.

(Issued separately, 27th June 1914.)

XX.—The Occurrence and Distribution of the Beetle, *Passalus unicornis*, Serv., in the Antilles and the Northern portion of South America. By Symington Grieve.

(Read 23rd February. MS. received 26th February 1914.)

IN the spring of 1906, when I spent some time exploring the interior of the mountainous island of Dominica, I came across this species when searching for the much larger and well-known beetle *Dynastes hercules*, Linn.

I had captured several specimens when moving about in the evenings, but had no idea of the numbers to be found until we began breaking up fallen and rotten trees in the forests. The nearer the timber approached to the state of touch-wood, the more numerous were the *Passalus unicornis*, Serv., to be found, as the softer the wood, the insects were able with greater ease to tunnel deeper into the logs. I found the larvæ in different stages of development, and also the mature beetles, some of them being the hosts of large numbers of parasitic mites. From what I saw, I came to the conclusion that the mature beetles moved about during the night, and returned to their burrows in the wood of the fallen trees with the return of daylight. These beetles are probably to be found at all elevations in Dominica in small numbers, but possibly only breed at elevations of over 1500 feet, as it was only at or over that height that I found the larvæ in the fallen and decayed trees.

The ravages of the insects, as far as I discovered, were confined to the dead wood of the fallen trees; but the long and large tunnels they made were of such a nature that the whole of the main stems were perforated by their burrowing, which was in almost every instance longitudinal to the stem.

It was to some extent by chance that I came across this beetle in its hidden tubes within the trees. When at a place at an elevation of about 2000 feet among the mountains, I heard that at times specimens of *Dynastes hercules*, Linn., could be obtained, and, as its distribution in the Antilles is somewhat remarkable, I was anxious to procure specimens.

Dynastes hercules, Linn., although abundant in the north of South America, is not found on any of the Antilles, except Dominica, and in the latter at times it becomes very rare, only once more to become abundant after the lapse of a period—probably from the occurrence of a number of fertile females during a certain year.

I took with me in my search seven or eight of my black men, armed with

machetes, and set them to cut up the decayed trees. These heavy swords with long chopper-like blades, with square tips, a thick back and sharp edge to the front, can do wonderful work in the hands of a black man expert in woodcraft.

After long search and breaking up of many trees, I found no specimens of *Dynastes hercules*, Linn., but many specimens of *Passalus unicornis*, Serv. The name given to this insect by the natives is the Vo-Vo, and I was unable to obtain any information as to its scientific name, even after my return to this country. At last the Rev. James Waterston, now engaged in the British Museum (Natural History), kindly offered his assistance. He enlisted the aid of Mr C. J. Gahan of the British Museum, who identified it as *Passalus unicornis*, Serv. Since then I have seen Mr Gahan, and he obliged by letting me view the collection under his care. I found that a specimen, in addition to the one given him by the Rev. Mr Waterston, already was in the British Museum, from Dominica, and also that the only other island of the Antilles from which specimens had been obtained was St Lucia. From the mainland of the north of the South American Continent were many specimens, especially from Ecuador and Colombia.

It therefore seems probable that this beetle has a distribution somewhat similar to that of its larger congener *Dynastes hercules*, Linn. The locality from which both beetles seem to have emanated, and at which they have still their strongest hold, is the mainland of South America, and it is an interesting problem that might at some future time be worth considering, as to how these insects and some other members of the South American fauna reached such a distant island as Dominica, without appearing on adjacent islands such as Guadeloupe or Martinique.

Passalus unicornis, Serv., is furnished with powerful apparatus by which it can cut its way into timber. While I have only seen it working in decayed wood, it may possibly be very destructive to living vegetation. This beetle has a prominent single horn on the upper part of its head, from which it derives its name.

The mites found upon *Passalus unicornis*, Serv., are possibly new to science. Mr Stanley Hirst of the Natural History Department of the British Museum, South Kensington, writes me, 21st February 1914:—

“The mites which you found on the beetle *Passalus unicornis*, Serv., belong to the genus *Euzercon*, but I cannot find out the name of the species, probably it has never been described.”

XXI.—Notes on the Reproductive Organs of the Pine Weevil (*Hylobius abietis*). By James W. Munro, B.Sc., Natural History Department, University of Aberdeen.

(Read 15th December 1913. MS. received 6th January 1914.)

THE reproductive organs of an insect have a three-fold interest: they are interesting to the anatomist; to the systematist they afford valuable secondary characters for the identification of species; the worker in economic entomology finds them of the first importance as a guide to the main facts in an insect's life-history.

The following description forms the groundwork of a research on the life-history of the pine weevil, one of the worst insect enemies of the forester in this country. With a large number of insects, and especially the moths, the life-history may be said to end almost as soon as the insect reaches the imago stage. With the pine weevil, on the other hand, the life-history is most interesting after the insect is adult.

In the larval stage *Hylobius abietis* is harmless. It is when it appears as the adult weevil that it becomes a serious danger to the forester. It then attacks young or newly planted conifers, and even hardwoods, gnawing the tender bark of the main stem and branches, and so killing the young plants. This damage is termed by the Germans the "*reifungs frass*," or ripening frass, and the name is singularly appropriate.

The following description of the reproductive organs of *H. abietis* is the result of work carried out in the Royal Forest Academy of Tharandt in Saxony, under the supervision of Dr Karl Escherich, Professor of Zoology in that Institute. I am greatly indebted to him for his advice and encouragement while engaged on it, and also to his temporary assistant, Dr Prell, of Marburg University, from whom I received valuable hints on the dissection of specimens and the making of preparations and sketches from them.

These notes are based largely on the examination of weevils found in the neighbourhood of Tharandt. I collected these as I required them from recently felled areas of Scots pine throughout the months of June and July of this year (1913). For the description of the genitalia I have used material collected in the neighbourhood of Schönefeld, in Saxony; and for revision work and biological observations, weevils collected in the neighbourhood of Aberdeen, Scotland.

The beetles for dissection were killed by chloroform, and examined immediately afterwards. The elytra and wings were first removed, and an incision made along each side from the anus anteriorly, and the terga removed.

Further dissection was done in a 75 per cent. solution of salt and water, under a Leitz simple dissecting microscope. The alimentary canal and its diverticula were removed, and the remainder of the dissection resolved into a teasing out of nerves, muscle, fibres and tracheæ, leaving the reproductive organs exposed. In the case of the male special care was necessary not to sever the testes from the vasa deferentia.

In making permanent preparations from dissections, these were fixed or hardened by gentle steaming, and then stained with carmine or hæmatoxylin, and reduced in acidified alcohol. They were then washed in 70 per cent., 80 per cent., and absolute alcohol, and mounted in Canada balsam in the usual manner.

The complete reproductive organs of *Hylobius abietis* have not yet been described. Nitsche¹ gives a small figure of the male organs without the penis. Fuchs² figures certain parts of the male and female genitalia. In neither case is any verbal description given.

In regard to the literature of the subject generally, I find that it is somewhat scanty, especially in works concerned with the genitalia. The only description in English of the genitalia of the weevils I have been able to refer to is Hopkins'³ *Monograph of the Genus Pissodes*. Of the German literature, the various papers by Fuchs, Verhoeff⁴ and Nusslin⁵ have been most useful.

THE FEMALE REPRODUCTIVE ORGANS.

These comprise the ovaries, the paired oviducts, the unpaired oviduct or uterus, the receptaculum seminis, the bursa copulatrix, and the vagina (Fig. 1). The accessory organs or genitalia consist of the seventh and eighth terga, the eighth sternum, and the so-called spiculum ventrale representing part of the ninth sternum.

The ovaries are two in number, lying on either side of the median line. They are attached to the fourth tergum. Each ovary consists of two egg-tubes, each opening into the paired oviducts. The terminal chambers are large, about one-fifth of the total length of the ovary in the mature weevil.

Below the terminal chamber the egg-tube resembles a string of pearls, due to the ova in it. The eggs are oval in shape, and in the egg-tubes lie up and down. In the paired oviducts of the mature insect, however, they may lie directly across them in an irregular group. At the junction of the egg-tubes

¹ Judeich and Nitsche, *Forstinsektenkunde*, 1888 ed., p. 58.

² *Morphologische Studien über Borkenpaper*, Part II., Munich, 1912.

³ Bulletin 87, American Bureau of Entomology.

⁴ Various papers in the *Deutsche Ento. Zeitschrift*, 1893-94.

⁵ *Leitfaden der Forstinsektenkunde*, 1913.

and the paired oviducts there appears, in the insect approaching oviposition, a brown substance, the corpora lutea.

The bursa copulatrix opens from the uterus as a diverticulum almost as large as that organ itself. At the base of the bursa the receptaculum seminis opens into the uterus by a long narrow tube (Fig. 2). This tube, together

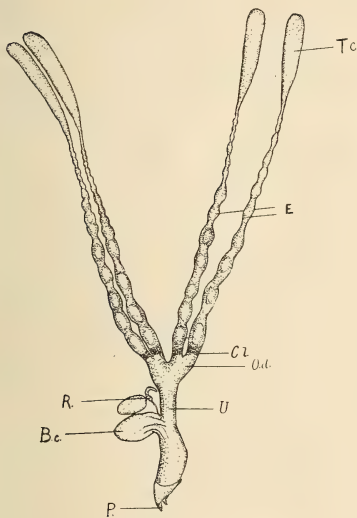


FIG. 1.

Female reproductive organs of *Hylobius abietis*.

- T.c.* Terminal chamber;
- E.* Egg-tubes;
- Cl.* Corpora lutea;
- Od.* Paired oviduct;
- U.* Uterus or unpaired oviduct;
- R.* Receptaculum seminis;
- B.c.* Bursa copulatrix.
- P.* Vaginal palpi.

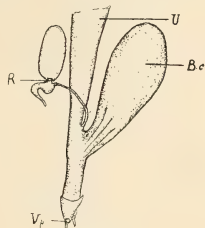


FIG. 2.

Portion of reproductive organs of *Hylobius abietis* highly enlarged.

- U.* Uterus;
- B.c.* Bursa copulatrix;
- R.* Receptaculum seminis;
- V.p.* Vaginal palpi.

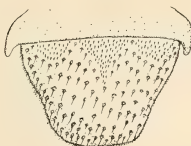


FIG. 3.

7th and 8th terga of female *Hylobius abietis*.

with the receptaculum, is clothed with muscle which serves to compress the sac and so cause the sperms to pass into the uterus for the fertilisation of the passing ovum.

The receptaculum seminis is a hook-shaped vesicle clothed with chitin, and appended to it is a sac-shaped diverticulum. Nusslin¹ calls this an

¹ Leitfaden der Forstinsektenkunde, 1913 ed., p. 269, fig. 235.

accessory gland (*anhangsdruse*), but it must be considered part of the receptaculum proper, for it proved on examination to be filled with sperms. It is most probably an accessory sac or reservoir.

Just below the bursa copulatrix is the vagina, surrounded by a band of chitin which binds the spiculum ventrale to it. It is further protected by two pore-bearing plates of chitin, ending in two papillæ, probably of use in oviposition.

The accessory organs of reproduction or genitalia of the female, as already mentioned, comprise the seventh and eighth terga, the eighth sternum, the spiculum ventrale, and the vaginal plates and palpi described above.

The eighth tergum (Fig. 3) is smaller than the seventh, which completely covers it. It bears numerous sense bristles. The seventh tergum is a broader plate. At its anterior end, where it adjoins the sixth, three semi-circular areas occur showing finer spinulæ than the rest of the segment.

The eighth sternum (Fig. 4) is a stout, broad plate, the edges of which are folded inwards a little.

The spiculum ventrale (Fig. 5) is a rod-shaped structure forking posteriorly into two lobes which are slightly thinner than the rod, and bear a number of stout bristles. It is attached to the eighth sternum by a web-like band of chitin.

THE MALE REPRODUCTIVE ORGANS.

These comprise the testes, the paired vasa deferentia with their sperm sacs and diverticula, the unpaired vas deferens, and the penis (Fig. 6).

The testes may be said to be four in number lying in pairs on either side of the median line. Viewed ventrally they appear as flat discs, laterally they appear double convex. Each disc appears to be made up of a number of segments. From the centre of each disc a short tube arises. These unite to form the paired vasa deferentia, which themselves unite to form the unpaired vas leading to the penis.

Midway between the testes and the unpaired vas, a short tube opens from the paired vasa and immediately branches into two long diverticula. Just below these short tubes the bulb-shaped sperm sacs lie.

The unpaired vas deferens is formed by the junction of the paired vasa, and for about a third of its length is of the same size. It then tapers suddenly, and, enclosed in chitin and exterior to that with muscle, winds in a zig-zag manner till it reaches the bulb of the penis. The bulb is considerably dilated and tapers halfway as the ejaculatory duct.

The male genitalia comprise the seventh and eighth terga, the eighth sternum, two chitinous sternal plates, and the fork or false spiculum gastrale (representing the ninth sternum), the ring and the sheath.

The eighth tergum (Fig. 7) in the male is larger than that in the female, and is not covered by the seventh.

The seventh tergum is also larger than that in the female. It is interesting to note that in the German examples of *H. abietis*, this segment bears what appears to be a rudimentary stridulating organ which is absent in the British examples, or in the rare cases when it occurs (I have found it only in two specimens) is barely perceptible.

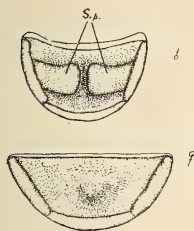


FIG. 4.

8th sternum of male and female *Hylobius abietis* respectively.

S.p. Sternal plates.

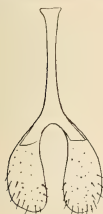


FIG. 5.

Spiculum ventrale.

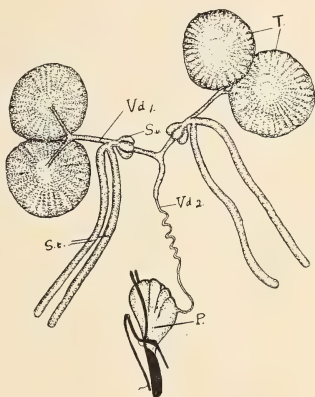


FIG. 6.

Male reproductive organs of *Hylobius abietis*.

- T.* Testes ;
- V.d.₁* Paired vasa deferentia ;
- S.v.* Seminal vesicle ;
- S.t.* Seminal tubes ;
- V.d.₂* Vas deferens ;
- P.* Penis.

On either side of the tergum is a row of bristle pits, fifteen to eighteen in number, from which project strong, short spinulae altogether different from the bristles and spines on the rest of the segment. In the British specimens these rows of spines are absent.

The eighth sternum (Fig. 4) of the male is narrower than that of the female. Attached to it are two sternal plates which serve to guide the penis when it is exerted. The chitinous parts of the penis consist of

the fork or false spiculum gastrale, the ring (the "gabel" of the German entomologists), and the sheath.

The fork (Fig. 8a), as its name indicates, is a long chitinous rod diverging at its posterior end into two short branches.

The ring (Fig. 8b) is a circular band of chitin encircling the bulb and sheath of the penis. It extends anteriorly as the anterior process, and posteriorly as the two posterior processes. These latter are finer than the first and bear a number of bristles.

The sheath (Fig. 8c.) consists of a fine plate of chitin, the edges of which overlap and partly enclose the ejaculatory duct. It extends anteriorly into two fine rods, the femora, which are attached to the ring and fork by muscle. Towards the base of the sheath two small plates arise from either side and serve further to hold the ejaculatory duct in position. At the posterior end of the sheath a few fine bristles occur. The sheath is the only portion of the penis exerted in copulation. In Fig. 6 the chitinous parts of the penis are viewed from the side; in Fig. 8 they are separated and viewed ventrally, the sheath in the same figure is also shown in its dorsal aspect to the right.

Figure 9 is a diagrammatic sketch showing the reproductive organs, or rather part of them, in situ, in both sexes.

The organs in both sexes extend from the fourth to the eighth abdominal segments.

THE BIOLOGICAL SIGNIFICANCE OF THE REPRODUCTIVE ORGANS.

It has been said that the development of the reproductive organs of an insect, whose life in the imago state is a long one, may be of great importance as a guide to the main facts in the life-history of that insect. This is most true of the reproductive organs in the female.

I have examined the organs of the male *Hylobius* immediately on pupation, and after five months had elapsed since pupation, and except that the sperm sacs and diverticula were small and undeveloped, the immature weevil differs but little from the mature one. With the female, however, the difference in development of the ovaries and the seminal pouch is very distinct.

In the month of April of this year I obtained a number of pupæ of *Hylobius*, and placed them, still in their pupal chambers, in a large breeding cage. I further planted several young Scots pine trees in the cage as food for them. In a week or two they emerged and commenced feeding. I left them untouched till the month of August, when I examined several. The ovaries were as shown in Fig. 1. Ova were present in the egg-tubes, and the

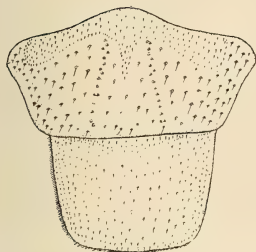


FIG. 7.

7th and 8th terga of male.

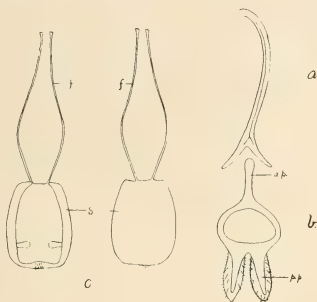


FIG. 8.

Chitinous parts of penis.

A. Fork ; B. Ring ; C. Sheath.

a.p. Anterior process ;

p.p. Posterior process ;

f. Femora ;

s. Sheath.

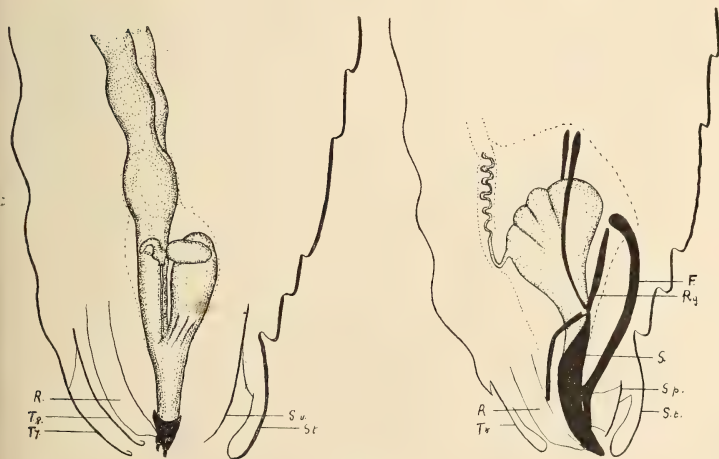


FIG. 9.

Posterior portions of male and female reproductive organs in relation to external parts.

F. Fork ; R.g. Ring ; S. Sheath ; S.p. Sternal plates ; S.e. Sternum of last segment ; R. Rectum ;

T₈ 8th Tergum ; T₇ 7th Tergum ; S.v. Spiculum ventrale.

seminal pouch was distended. The corpora lutea was also present. Towards the end of September I obtained more pupæ just about to emerge, and these I examined. The ovaries were quite undeveloped. The receptaculum was very much reduced, and there was no sign of ova

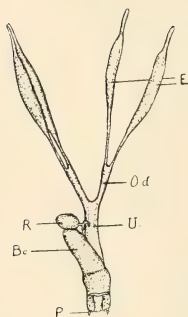


FIG. 10.

Immature female reproductive organs of *Hylobius abietis*.

- E.* Egg-tubes ;
- O.d.* Paired oviduct ;
- U.* Uterus ;
- R.* Receptaculum seminis ;
- B.c.* Bursa copulatrix ;
- P.* Vaginal palpi.

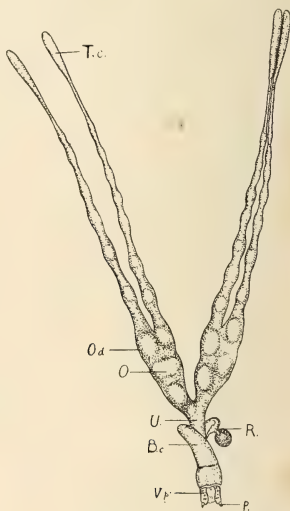


FIG. 11.

Mature female reproductive organs of *Hylobius abietis*.

- T.c.* Terminal chambers ;
- O.d.* Paired oviduct ;
- O.* Ovum ;
- U.* Uterus ;
- R.* Receptaculum seminis ;
- B.c.* Bursa copulatrix ;
- V.p.* Vaginal plates ;
- P.* Vaginal palpi.

in the short egg-tubes (Fig. 10). Now this is the condition of the ovaries in all the newly emerged females of *Hylobius* which I have examined. A number of weevils, evidently belonging to a late breed, were examined in Tharandt in the month of June, and the stage of development was identical with the preceding. Accordingly Fig. 10 represents the ovaries of the newly emerged *Hylobius*.

About the middle of September I again examined the weevils in my breeding cage. The condition of the ovaries is shown in Fig. 11. The ova are large, and some are descended into the paired oviduct; egg laying is just about to take place.

In October I examined all those left in the breeding cage, but unfortunately all were males. However, I have succeeded in figuring three stages in the development of the adult *Hylobius*.

Fig. 10 depicts the unripe ovaries, which I may call the first stage. Fig. 1 depicts the half mature ovaries, the second stage; and Fig. 11 represents the fully mature organs, the third stage.

Further, from the first stage until the second stage is reached four months must elapse, and from the first stage till the third stage, over five months must intervene.

Accordingly it is apparent that a weevil appearing in March or April cannot reproduce until September or October. Further, as the weevil is known to lie resting over the winter, it is more than probable that the egg for a second generation cannot follow till March of the following year.

Many problems must still be tackled before the life-history of *Hylobius* is clear. Is there a third brood possible, and, if so, when would it appear? What period covers the life-history from the egg to the adult?

These two questions are the subject of my research at present, and I hope I may be able to shed some light on them in a later paper.

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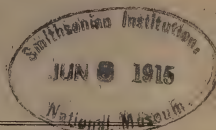
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XXII.—An Account of the Bird-lice of the Genus *Docophorus* (Mallophaga) found on British Auks (*continued*). By James Waterston, B.D., B.Sc., Imperial Bureau of Entomology.

(MS. received 15th September 1914. Read 26th October 1914.)

(B) MORPHOLOGICAL—THE MALE GENITALIA.

THAT the male genitalia of the Mallophaga as a group afford easily recognised and exact specific characters is becoming increasingly evident. So very sharply defined indeed are the chitinized portions of these organs, that it is in many cases possible by this means to determine accurately mere fragments of insects so bleached and rubbed as to be otherwise unrecognisable. Before describing in detail the species of Auk *Docophori*, already referred to, I think it useful to figure and annotate the external ♂ sexual apparatus of each, and to indicate shortly, by a table, how the five forms may thus be separated without recourse to any other characters.

The descriptive terms now employed have in part been recently introduced, and all are explained in *Ann. South Afr. Mus.*, vol. x., pt. ix., No. 14, pp. 279, 280, July (1914). The following short account will make subsequent description more intelligible:—

The copulatory apparatus (♂) in *Docophorus*, *Nirmus*, etc., consists of an internal chitinized lamina—the *basal plate*—to which many strong muscles are attached. Distally this plate bears a pair of laterally placed, freely movable blades (*paramera*), within which are two basally articulating and practically fixed more leaflike sclerites (*endomera*), from which issue apically a much smaller pair of *telomera*. Together the parts within the *paramera* may be referred to as the *mesosome*. The true *penis* is a simple chitinized tube lying immediately below, and often greatly exceeding in length, the *telomera*. The path of the *penis* inside the *mesosome* is as a rule easy to discern, especially apically. The *hypomeron* is the inferior support of the *penis*. When distinct it takes the form of a triangular, apically reflexed, hardly thickened membrane. Oftener it appears as the expanded base of the *penis*. These terms are purely descriptive, at present. The exact nature of the parts to which they apply has still to be ascertained.

The genitalia of *Docophorus acutipectus* show the typical parts clearly, and in Fig. 1 they have been separately labelled. No difficulty should be experienced in homologising the parts in the other species.

Docophorus acutipectus, Kell.

The basal plate is much longer (3:2) than, though hardly so wide as, the exerted portion of the apparatus. The paramera are broad, especially at the base which, on the inner side, is slightly doubly concave. The anterior and posterior angles of the base are distinct though rounded. The sulcus of articulation with the endomera is neither deep nor extensive. Its superior and inferior edges are parallel. Each parameron is a little broader medianly than at the base, and beyond the middle contracts rather sharply to a point. The ventral hair is at three-fifths. The sides of the paramera are continuously curved, and the outer is markedly convex.

The endomera are triangular in shape, convex externally, and doubly concave internally below. The median clear area is thus constricted at a point

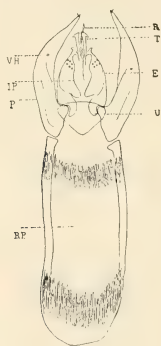


FIG. 1.

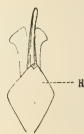
Docophorus acutipectus.

FIG. 1A.

Docophorus acutipectus from below
showing Hypomeron.

B.P. Basal plate. P. Parameron. V.H. Ventral Hair. E. Endomeron.
I.P. Inner Pattern. U. Uncus. T. Telomeron. H. Hypomeron. Pe. Penis.

beyond three-fourths. The basal uncus of the endomeron is well developed and closely adherent to the base of the parameron. Apex of endomera blunt, recurved and thickened, as is likewise the whole outer edge. There are about seven pre-apical ventral hairs in two rows on each endomeron.

The hypomeron is very broad and short. It is applied to the penis at the level of the apices of the endomera.

The telomera are particularly distinct. Each consists of a narrow

chitinous strip or neck and a triangular head—the neck being much longer than the head or that portion of the penis which projects beyond.

The penis is generally straight.

Length of the apparatus from tip to posterior edge of basal plate about .46 mm.

Docophorus calvus, Kell.

The basal plate is barely so long as in *acutipectus*. In the proportion of 4:3 to the rest of the apparatus. The paramera are broad and straight for more than two-thirds of their length. Thereafter they contract suddenly—the bend being more abrupt on the inner edge. Ventral hair at two-thirds. Base of paramera heavily chitinized and quadrangular in shape. The upper edge of the articulation with the mesosome not nearly above the lower, which protrudes as a thin ventral lamina clasping the base of the mesosome.



FIG. 2.
Docophorus calvus.

The mesosome is conspicuous, filling all the space between the closed paramera. In shape it is an isosceles triangle with blunted apex. The endomerai unci are small and strongly curved. The endomera are closely approximated. The ventral pattern does not reach so far back as in *acutipectus*, and its constriction is almost median. Each endomeron bears near the apex at the side three hairs in a row, and one a little behind these but below. Apices of endomera truncate and hardly

reflexed. The telomera are linear, inconspicuous and projecting little beyond the endomera.

The penis is a little bent.

The hypomeron is long, narrow, and ends before the apex of the endomeron.

Length of the apparatus .5 mm.

Docophorus celeodoxus, N.

The proportion between the basal plate and the free part of the apparatus is the same as in *calvus*, 4:3.

The paramera are similar to those of *calvus*, but are not so robust and broad, neither are they so abruptly bent. The ventral hair is rather nearer the base than in *calvus*, well within two-thirds. Upper distal angle of basal articulation distinct,

The mesosome does not fill entirely the intra-parameral area; nor does it end truncately as in *calvus*. Distally the endomera are loosely separate—their apices being somewhat drawn out and recurved. The hairs of



FIG. 3.
Docophorus celeodoxus.



FIG. 5.
Docophorus megacephalus.



FIG. 4.
Docophorus merguli.



FIG. 4A.
Docophorus merguli, to show
Hypomeron.

the mesosome are sometimes indistinct. They are pre-apical and ventral, placed at the side of the inner clear area which, in this species, is not constricted,

From their base outwards the telomera are gradually expanded into a distinct head, whose distal edges slope sharply.

The penis just reaches beyond the telomera.

The hypomeron is as in *calvus*.

Length of the apparatus, .5 mm.

***Docophorus merguli*, D.**

The basal plate is at its widest anteriorly, and is little longer than the extruded apparatus. The paramera are long and narrow, except on their basal third. The ventral hair *before* half.

The outer sides of the endomera are practically straight and parallel to one another. The distal edge of each slopes slightly towards the penis but does not run directly to that part, there being a somewhat pronounced notch on each side of the penis. The endomera are not apically produced and reflected, thus in association they present a quadrate facies. Each endomeron bears distally 4-5 ventral hairs. Apically the endomera are somewhat apart.

The central pattern of the mesosome is pear-shaped; the basal articulation short and narrow.

The telomera, hypomeron and penis are closely associated. The former may be distinguished, by careful dissection, as two short, broad processes which do not form a head or hook.

The hypomeron seems inseparable from the penis, which appears as if thickened basally. Owing to the small size of the endomera the penis-hypomeron in this and the following species projects conspicuously.

Length of apparatus, .35 mm.

***Docophorus megacephalus*, D.**

The basal plate is, in proportion to the exerted part of the genitalia, even shorter than in *merguli*. The plate is also more coloured than in the others of the group, being entirely dark save for a short semi-circular space near the junction of the paramera, and another spot in front. Bases of the paramera evenly rounded on the upper internal aspect. The paramera are broad to beyond half, and thereafter contracted gradually on the outer edges, while the inner remain straight. The ventral hair is placed just beyond half.

The endomera are roughly triangular with curved sides, and are widely apart distally, without any recurved apex. Their inner edges are convergent without actually meeting. On inner ventral edge of each parameron from the

apex backwards are 4-5 hairs, placed 3 near the apex and one at least farther back. Endomera considerably less than half the length of the paramera.

The penis is bent and is closely united with the telomera and hypomeron. As in *merguli* it is conspicuous.

Length of the apparatus, .44 mm.

KEY TO SPECIES OF DOCOPHORI FROM BRITISH AUKS, BASED ON
CHARACTERS OF MALE GENITALIA ALONE.

1. Paramera evenly bent from base to apex, *i.e.*, neither outer nor inner edge abruptly turned at any point (3).
Paramera suddenly bent and narrowed towards apex (2).
2. Telomera linear: inner pattern of mesosome constricted (*D. calvus*).
Telomera distally expanded: inner pattern of mesosome unconstricted (*D. celedoxus*).
3. Telomera free, stalked and capitate, longer than the projecting portion of the penis. Hypomeron distinct (*D. acutipectus*).
Telomera shorter than the projecting portion of the penis, with which and the hypomeron they are apparently fused (4).
4. Paramera long and narrow: ventral hair before half, sides of mesosome parallel or subparallel (*D. merguli*).
Paramera narrower on apical third, ventral hair beyond half, sides of mesosome slanting inwards (*D. megacephalus*).

(Issued separately, 20th April 1915.)

XXIII.—A Second Contribution to the Spider Fauna of Scotland;
with Description of a New Spider of the Genus *Clubiona*.

By A. Randell Jackson, M.D., D.Sc. (Communicated by Wm. Evans,
Esq., F.R.S.E.)

(With Plate.)

(MS. received 21st October 1914. Read 26th October 1914.)

IN June 1914 I spent a fortnight in Scotland and devoted my time to collecting spiders. I obtained 139 species of these. Of this number seven were previously unrecorded for Scotland, and two of these were also new to Britain. These species are:—

- Dismodicus elevatus* C.L.K.
- Micryphantes nigripes* Sim.
- Coryphæus fortunatus* Camb.
- Metopobactrus prominulus* Camb.
- Agyneta decora* Camb.
- Bathyphantes pullatus* Camb.
- Theridion impressum* L. Koch.

The first two of these are now recorded for the first time as British.

Last year in Scotland I obtained eight additions to the British fauna,¹ and this year I rediscovered five of these in different parts of the Highlands.

The localities visited were Loch Lomond, Glencoe, Fort William, Glenfinnan, Loch Laggan, Rothiemurchus Forest, and the slopes and summits of Ben Lomond, Ben Nevis, Ben McDhui, Cairntoul, and Cairngorm. In some of these only a very short time was spent, and with the exception of Rothiemurchus Forest the others only had a day each.

There is still a very large amount of work to do in the Highlands of Scotland amongst the spiders. Probably it is now the most lucrative part of Britain as regards the making of additions to our fauna. This is especially the case with the mountain summits.

On June 3rd and June 4th, the following species were picked up on the shores of Loch Lomond:—

- Lycosa agricola* Thor.
- „ *amentata* Clerck.
- Diplocephalus picinus* Bl.
- Typhochrestus digitatus* Camb. Females only.
- Gongylidiellum vivum* Camb.
- Cedothorax agrestis* Bl.
- Maso Sundevallii* Westr.

¹ *Proc. Roy. Phys. Soc. Ed.*, vol. xix, part 5, p. 108.

On June 4th, Ben Lomond was ascended on a most beautiful day and under very favourable conditions. There was no snow on the summit, which has an altitude of 3192 feet. The results were, however, disappointing, few of the genuine mountain species appearing, and these only in small numbers. The summit is much smaller than it looks from below, and not very stony in character. The following species were obtained :—

Below 2000 feet :—

Lycosa pullata Clerck. Abundant.
Tarentula pulverulenta Clerck. Males and a single female.
Cnephalocotes elegans Camb. One male.
Diplocephalus permixtus Camb.
Lophomma punctatum Bl.
Dicymbium nigrum Bl.
Neriere rubens Bl.
Odothorax retusus Westr.
 „ *tuberosus* Bl.
Walckenaëra nudipalpis Westr.
Linyphia pusilla Sund.
Mitopus morio Fabr. Young examples only.

Most of these were obtained in a swamp. The specimens of *T. pulverulenta* were very large and distinctly marked.

Near the summit :—

Robertus lividus Bl.
Cnephalocotes elegans Camb. Males only.
Hilaira frigida Thor. Three females.
Macrargus adipatus L. Koch. One female.
Centromerus arcanus Camb. One female.
Micryphantes sublimis Camb. Both sexes.
Leptyphantes Zimmermannii Bertk. One male.
Mitopus morio Fabr. Young examples.
Obisium muscorum Leach.

On June 5th, the following were picked up during the passage of Glencoe. The day was very wild and a good deal of rain fell :—

Drassodes lapidosus Walck.
Neon reticulatus Bl.
Trochosa terricola Thor.
Robertus lividus Bl.
Micryphantes sublimis Camb. One female.
Leptyphantes Zimmermannii Bertk. One female.
Epeira cornuta Clerck. Immature example.

Second Contribution to Spider Fauna of Scotland. 179

On June 6th, Ben Nevis was ascended. There was about eight feet of snow on the summit, which was enveloped in clouds and bitterly cold.

Specimens were taken chiefly from three areas.

About 2000-2200 feet :—

Cryphæa silvicola C.L.K.

Theridion bellicosum Sim. Both sexes. Males much rarer than females.

Robertus lividus Bl.

Walckenaëra capito Westr. One female.

Micryphantes sublimis Camb. Two males.

Leptyphantes Zimmermannii Bertk.

„ *Whymperii* F. Camb. One female.

Obisium muscorum Leach.

This locality was the scree bed above the half-way house.

Between 3000 and 3500 feet the following occurred :—

Styloctetor morula Camb. Two females.

Entelecara errata Camb. Both sexes.

Erigone tirolensis L. Koch. Both sexes.

Coryphæus mendicus L. Koch. Two females.

Hilaira frigida Thor. Females only.

Leptyphantes cacuminum Jackson. One female.

Nemastoma chrysomelas Herbst. One male.

Over 4000 feet :—

Entelecara errata Camb.

Coryphæus mendicus L. Koch.

Hilaira frigida Thor. Not rare.

Macrargus adipatus L. Koch. One female.

Leptyphantes cacuminum Jackson. One female.

„ *Whymperii* F. Camb. Females.

Linyphia pusilla Sund. One male.

„ *clathrata* Sund. One male.

The occurrence of the two species of *Linyphia* is very unusual in such a situation. No doubt each had reached the place on a chance aeronautic excursion. Both were found under stones, the specimen of *clathrata* in a very snowy neighbourhood not far from the summit. Spiders of all species were much rarer than in 1913. I was on Ben Nevis in that year a week later, but there was far more snow about then than in the present year.

June 7th was wet, but a good deal of work was done round Fort William. The following species were obtained:—

Corpach Moss:

- Scotina gracilipes* Bl. An immature example.
- Trochosa terricola* Thor.
- Dictyna arundinacea* L.
- Theridion impressum* L. K. Both sexes on gorse bushes.
- Robertus lividus* Bl.
- Dismodicus bifrons* Bl. One female.
- Tetragnatha extensa* L.
- Obisium muscorum* Leach.

This might be a useful locality on a nice day.

Pine wood above Fort William:

- Clubiona reclusa* Camb.
- „ *trivialis* L. Koch.
- Lycosa amentata* Clerck.
- „ *pullata* Clerck.
- Ciniflo fenestralis* Strøm.
- Ceratinella brevipes* Westr.
- Lophocarenum nemorale* Bl. Females only.
- Cnephalocotes elegans* Camb. One female.
- Wideria antica* Wid.
- Agyneta conigera* Camb.
- Pœciloneta globosa* Wid.
- Leptyphantes Mengii* Kulcz.
- Labulla thoracica* Wid.

Most of these specimens were found amongst moss on the trunks of pines. These trees are, however, quite young, the wood being apparently a plantation.

June 8th was spent at Glenfinnan near the head of Loch Shiel. The following species were obtained:—

- Xysticus cristatus* Clerck.
- Philodromus emarginatus* Schranck. Young examples only.
- Lycosa amentata* Clerck.
- Dictyna arundinacea* L.
- Theridion sisypium* Clerck.
- Robertus lividus* Bl.

Tiso vagans Bl.

Diplocephalus permixtus Camb.

Pocadicnemis pumila Bl.

Entelecara trifrons Camb.

Cornicularia vigilax Bl. One male.

Ædothorax retusus Westr.

Erigone dentipalpis Wid.

Hilaira uncata Camb.

Leptorhoptrum Huthwaitii Camb.

Agyneta decora Camb. Both sexes in flood refuse.

Microneta viaria Bl.

Bathyphantes pullatus Camb. Females on heather.

Leptyphantes obscurus Bl. Common.

Pachygnatha De Geerii Sund.

Tetragnatha extensa L.

Nesticus cellulanus Clerck. A male under a stone on the railway embankment.

Epeira cornuta Clerck.

„ quadrata Clerck. Immature specimens.

Megabunus insignis Meade.

On June 7th, the following occurred in flood refuse on the shore of Loch Laggan near the hotel:—

Diplocephalus frontatus Bl.

" cristatus Bl.

Micryphantes rurestris C.L.K.

Drassodes troglodytes C.L.K.

My friend, Mr W. E. Brown, ascended Cairngorm by himself on June 11th. On June 13th we both climbed Ben Mc Dhui, and on June 15th Cairntoul. Aviemore was our base.

The following species were obtained by our united efforts :—

Cryphœca silvicola C.L.K. Ben McDhui at 2900 feet.

Pirata piratica Clerck. Loch Eunach, 1650 feet.

Lycosa amentata Clerck. Cairntoul, 3000-3500 feet. These specimens are all very large and show several small differences from typical examples. They were exceedingly abundant on the grassy plateau.

Tarentula pulverulenta Clerck. Both sexes in the same situation.
The specimens are very large and distinctly marked.

- Trochosa biungiculata* Camb. A splendid male on Cairntoul at 3100 feet was taken amongst numerous members of the two preceding species (see page 188).
- Tiso æstivus* L. Koch. Both sexes, under stones. Over thirty specimens were obtained, most being females. Cairngorm at 3500 feet, and Ben McDhui on the plateau and up to the summit, 4296 feet.
- Caledonia Evansii* Camb. Females only. Cairngorm at 3500 feet and Ben McDhui at 4000 feet.
- Cornicularia Karpinskii* Camb. Two females under stones on the summit of Cairntoul, 4241 feet.
- Walckenaëra capito* Westr. One female at the summit of Cairntoul.
- Erigone tirolensis* L. Koch. Females on Cairntoul at the summit, and at 4000 feet on Ben McDhui.
- Erigone arctica* White. Both sexes under stones on the shores of Loch Eunach, 1650 feet. The specimens resemble the typical form but want the denticle on the under surface of the palpal tibia.
- Erigone dentipalpis* Wid. A pair with the last species.
- Cedothorax agrestis* Bl. A female in the same situation.
- Coryphæus mendicus* L. Koch. Both sexes on the summits of Ben McDhui and Cairntoul.
- Hilaira frigida* Thor. Cairngorm 3500 feet, Ben McDhui summit, Cairntoul summit.
- Micryphantes sublimis* Camb. A male on Ben McDhui at about 3500 feet.
- Micryphantes nigripes* Simon. Females on Cairngorm at 3500 feet. Females on Ben McDhui at 3500-4296 feet. A male on Ben McDhui at about 3800 feet. This species was new to Britain. The females were found with their egg sacs under stones, and the males are probably more numerous earlier in the year (see page 186).
- Leptyphantes Zimmermannii* Bertk. Loch Eunach at 1650 feet. Ben McDhui at 4000 feet.
- Leptyphantes cacuminum* Jackson. Summit of Cairntoul.
- „ *Whymperii* F. Camb. Ben McDhui, 2900 feet; summit of Cairntoul.
- Mitopus morio* Fabr. Immature examples at Loch Eunach.

Altitude on the Cairngorms was determined by means of an aneroid barometer.

The Cairngorm mountains differ in several respects from Ben Nevis and the other mountains on which I have collected. For example, on June 6th, there was eight feet of snow on Ben Nevis at 4406 feet, whilst on June 13th, Ben McDhui with a height of 4296 feet was free except in some of the deepest corries. The Cairngorm mountains have an immense bulk, and their summits all rise from a lofty plateau about 3500 feet in height. This is covered with coarse grass and frequented by abundant *Lycosids* which, in some other parts of Scotland, seem conspicuous by their absence at high elevations. The great size and remoteness of these peaks makes them difficult of access. The easiest way—as I now know—is to cycle up to Loch Eunach and thence work Cairntoul and Braeriach.

On June 10th, 11th, and 12th, Rothiemurchus forest was worked. I include in this, Glenmore forest, and Abernethy forest, but did little in the two latter localities. The following animals were obtained:—

- Segestria senoculata* L.
- Oonops pulcher* Templ.
- Drassodes lapidosus* Walck.
- Clubiona trivialis* L. K.
- Clubiona comta* C.L.K.
- Chiracanthium carnifex* Fabr. A female in Abernethy forest.
- Zora nemoralis* Bl. One female.
- Micaria pulicaria* Sund. Immature examples.
- Xysticus cristatus* Clerck.
- Oxyptila trux* Bl.
- Philodromus aureolus* Clerck. One male only.
- „ *cespiticollis* Walck. Not rare.
- „ *emarginatus* Schranck. Both sexes, occasional.
- Salticus cingulatus* Panz.
- Neon reticulatus* Bl.
- Evophrys erraticus* Walck. An adult male, and a young female.
- Evarcha falcata* Bl. One male.
- Cryphæa silvicola* C.L.K. Adult females and young; common.
- Textrix denticulata* Oliv. Adult female.
- Hahnina montana* Bl.
- Pisaura mirabilis* Clerck. A single adult female, and a few young.
- Trochosa terricola* Thor.
- „ *perita* Latr. On the sandy shore of Loch Morlich.
- Tarentula pulverulenta* Clerck. Both sexes.

Tarentula barbipes Sund. Immature specimens, probably referable to this species.

Lycosa amentata Clerck. Common.

„ *lugubris* Walck. Common.

„ *pullata* Clerck. Common.

„ *prativaga* C.L.K. One female at Loch an Eilean.

„ *nigriceps* Thor. One female.

„ *palustris* L. One male.

„ *agricola* Thor. Common at Loch an Eilean (840 feet).

Dictyna arundinacea L. Abundant on heather.

„ *pusilla* Westr. Rather common on the lower boughs of conifers and on juniper bushes. This species was taken in Rothiemurchus forest by Mr W. Evans in 1895, but was recorded accidentally as *D. uncinata* Westr. Through the kindness of the authorities of the Dublin Museum I have been able to examine these specimens, which are genuine examples of *D. pusilla*.

Ciniflo fenestralis Ström. Not rare under bark.

Theridion sisypium Clerck. Abundant.

„ *impressum* L. Koch. One male.

„ *varians* Hahn. One pair only.

„ *bellicosum* Sim. A male and two females under stones on a crag overlooking Loch an Eilean.

Robertus lividus Bl.

Pholcomma gibbum Westr. One female.

Theonoe minutissima Camb. Rare.

Ceratinella brevipes Westr.

Cnephalocotes obscurus Bl.

Diplocephalus fuscipes Bl.

Tapinocyba pallens Camb.

Lophomma herbigradum Bl.

Pocadicnemis pumila Bl.

Peponocranium ludicrum Camb.

Metopobactrus prominulus Camb. One female; new to Scotland.

Minyriolus pusillus Wid.

Entelecara erythropus Westr.

Evansia merens Camb.

Wideria cucullata C.L.K.

Cornicularia cuspidata Bl.

Nerienne rubens Bl.

„ *rubella* Bl.

Dismodicus elevatus C.L.K. A male beaten from a juniper bush in Abernethy forest between Rynettin and Forest Lodge. New to Britain (see page 187).

Edothorax agrestis Bl.

„ *retusus* Westr.

„ *apicatus* Bl. Near Kingussie.

Erigone dentipalpis Wid.

Erigone atra Bl.

Coryphæus fortunatus Camb. One female. New to Scotland.

Hilaira excisa Camb.

Macrargus abnormis Bl.

Rhabdoria diluta Camb.

Centromerus arcanus Camb.

Syedra innotabilis Camb. One male.

Agyneta cauta Camb. Both sexes.

„ *subtilis* Camb. Two males.

„ *conigera* Camb. Common.

Microneta viaria Bl.

Bathyphantes concolor Wid.

Leptyphantes ericæus Bl.

„ *obscurus* Bl. Common.

„ *Zimmermannii* Bertk.

„ *tenebricola* Wid.

„ *expunctus* Camb. Abundant on the lower branches of conifers in many parts of the forest. Both sexes were adult.

Linyphia clathrata Sund. One male.

„ *peltata* Wid. Common.

„ *pusilla* Sund.

Tetragnatha extensa L.

Meta segmentata Clerck.

Cyclosa conica Pallas. One male.

Epeira cucurbitina Clerck. One male and two females. Typical.

„ *Sturmii* Hahn. Both sexes on conifers.

„ *quadrata* Clerck. Immature specimens.

„ *cornuta* Clerck. Females only.

„ *umbratica* Clerck. One young male.

Obisium muscorum Leach.

Platybunus corniger Herm. Not rare.

Mitopus morio Fabr. Young specimens; common.

With about a dozen or fifteen exceptions none of these species were

common, most of the records being based on one or two examples chiefly females.

Philodromus emarginatus, *Lycosa pratiraga*, and *Dictyna pusilla*, are generally regarded in Britain as southern forms. Perhaps the chief feature was the abundance of *Dictyna pusilla* and *Leptyphantus expunctus*. I was surprised at my failure to get the Raunoch animals *Clubiona subsultans* Thor., *Zilla Strömii* Thor., and *Robertus scoticus* Jackson. I worked specially for these, and their absence from my list is thus the more noteworthy.

NOTES ON SEVERAL SPECIES.

Micryphantes nigripes Simon.

[Plate V. Figs. 1 and 2.]

Microneta nigripes Simon. Arach. de France, v., pp. 439, 440, figs.

Micryphantes nigripes Sim. De Lessert, Cat. des. Invert. de la Suisse; Araignées, pp. 233, 234, fig.

I have so named the species taken on the Cairngorm mountains and recorded above. I think this is correct, but no direct comparison of specimens with the types has been made. After the present continental war is concluded this will have to be done.

Mr Simon's original figures, in the *Arachnides de France*, do not show the lamella characteristica of the male, which is absolutely necessary for the diagnosis of these species. Dr de Lessert however figures this, and though his figure was apparently done under smaller magnification than mine, I believe the species to be identical.

The male of this species taken by me is 1.75 mm. in total length. Its general facies is that of a very dark example of *M. sublimis* Camb., or *M. rurestris* C.L.K. The absence of the curved process at the inner side of the base of the palpal tarsus easily distinguishes it from the former, and the shape of the lamella characteristica from either (see Fig. 2). Eyes as in the female.

The females vary in length from 1.8 to 2.1 mm. They are of a dark brown, usually nearly black, colour. The legs are all dark brown. Palpi dark brown, the last two joints darkest.

The vulva is extremely like that of *M. rurestris* C.L.K., and *M. sublimis* Camb., but darker than either. In shape it more closely resembles the former species, but is often rather broader and in fact somewhat intermediate between the two.

The falcate armature and chaetotaxy are typical of *Micryphantes*, and the

first and second tibiae lack the posterior lateral spines which occur in some species of this genus but which are again absent in *M. rurestris* and *M. sublimis*.

The only means of recognising the females of this species appears to be by the relations of the eyes.

In *M. rurestris* and *M. sublimis* the posterior row is practically straight. The eyes are practically equal and equidistant. If there is any difference the centrals may occasionally be very slightly larger, and very slightly nearer the laterals than each other.

In *M. nigripes* the posterior row is fairly distinctly curved in a line concave in front. The centrals are *much* larger than the laterals, and *much* nearer to them than to each other. The centrals are very large and round and generally have a pearly lustre.

I don't know whether this is invariable, but it obtains in all of the dozen examples I have seen.

M. nigripes Sim. has only hitherto occurred on the French and Swiss Alps at high altitudes. Dr de Lessert found it under stones up to 2800 metres. He states that the male becomes adult in August. I only found one example of this sex, the remainder being females with egg sacs. This is of course the first British record.

Dismodicus elevatus C. L. K.

[Plate V. Figs. 3 and 5.]

As stated above, I obtained a single male of this well-known continental species in Abernethy forest where it was beaten from a juniper bush.

It differs distinctly from the common *D. bifrons* Bl. in caput and palpi. My specimen is rather larger than the average of that species, measuring 1.85 mm. in total length. *D. bifrons* Bl. does, however, reach this sometimes. Looked at from the side the caput of *D. elevatus* is higher, more massive, and more globular than that of *D. bifrons*. From above, the sides appear much more convex and the two lobes much more divergent posteriorly. The sides appear very convex, again, when seen from the front, and the central depression between the lobes is less evident. The palpal differences are even more marked.

In *D. elevatus* the tibia seen from above is very broad, and its external apical angle is produced into an apophysis directed upwards and outwards and very visible from the inner side of the organ. As there seem to be no figures of the tibia in the latter position I give some, and also show the base of the tarsus. This, in *D. elevatus*, is produced backwards and downwards on to the inner side of the tibia as a curved apophysis.

In *D. bifrons* neither the external apical angle of the tibia nor the base of the tarsus is so produced.

Only very minute differences are present in the palpal organs.

D. elevatus has not previously occurred in Britain. It is rare in France, and occurs also in Belgium, Switzerland, Prussia, Holstein, Bavaria, Silesia, Galicia, Hungary, and Sweden.

It is generally obtained from the lower branches of conifers, and, in France, is adult in May and June.

Trochosa biunguiculata Camb.

I found a single male on Cairntoul at 3100 feet. This species has occurred twice before in Britain, viz., a male at Braemar by Professor Trail, and a female on Cairntoul by Mr W. Evans.

Continental writers have assumed that this is the *L. alpigena* of Doleschal. I don't know on what evidence this assumption is made, but I daresay our species is identical with that figured by Professor Kulczynski in *Symb. ad faunam Aran. Austriae inferioris*, 1898, pp. 105 and 106, pl. ii, figs. 81 and 82.

L. alpigena has occurred, according to these authors, in Greenland, Tyrol, and Switzerland. In the last country, according to Dr de Lessert, it has been taken at from 1000 to 2800 metres of altitude.

A comparison of British with continental examples is necessary before any change of name is justifiable.

DESCRIPTION OF A NEW SPIDER OF THE GENUS CLUBIONA.

CLUBIONA HUMIDA sp. nov.

[Plate V. Figs. 7, 8, 9, 10, 11.]

Size.—Total length between 5 and 6 mm., females rather larger than males.

Colour rather variable. *Cephalothorax* yellow-brown above. A short longitudinal black line usually marks the thoracic juncture, and this may or may not give out fine lines radiating to the borders of the carapace. *Sternum* yellow-brown, rather darker at the edges. *Abdomen* yellow-brown, red-brown, or dark brown. A dark central dorsal longitudinal mark of a lanceolate shape is present, which does not extend far below the middle of the length and usually falls short of this. Numerous yellow-brown marks are sprinkled over the abdomen. On the

dorsal surface there are usually a pair of large ones placed one on each side of the lanceolate mark, about its middle. Towards the posterior end smaller ones are arranged to form a series of indistinct chevrons, the apices of which point forwards and are in the middle line. On the ventral surface these spots are arranged to form four more or less distinct parallel rows.

The females are darker than the males, especially on the abdomen, which is usually quite dark brown and in the region of the caput which is generally rather deeply pigmented.

The tibiæ of the third pair of legs each bear two spines beneath.

There is nothing characteristic in the size, colour, or facies of this species, which in these respects closely resembles *C. grisea* L. Koch., and others of the genus. The species is, however, easily recognised in both sexes by the structure of its sexual organs.

Palpus.—The tibia is pale yellow-brown in its basal half. The apex and apophysis are deeply pigmented.

The apophysis is as usual in the genus placed at the external part of the apex of the tibia. It is of the trifid type and is divided into three branches, a superior, an external, and an inferior. The superior branch runs obliquely forwards and outwards, and projects on the outer side of the article. Its anterior border is at first straight but afterwards slightly concave in front. From underneath the straight part a strong bluntly pointed extra apophysis projects forward. This is visible in nearly all positions of the organ, and is highly characteristic, being found in none of the allied species.

The external apophysis is inconspicuous, forming a short knob between the superior and inferior apophyses and projecting on the outer side of the article. The third or inferior apophysis is shaped like a harpoon with one barb, as is the case in *C. grisea* and other species. Here, however, the apophysis is longer and rather differently shaped. The barb also is longer and slenderer.

Palpal organs.—The apical organs, whilst resembling those of other species, are readily recognisable. The pale external process reaches or slightly passes the end of the tarsus. The dark or internal process is a good deal shorter. Its external border, for nearly the whole of its length, is bent downwards almost at right angles to the body of the process. The apex of this bend is obliquely truncated, and from below the sharp subtriangular end of the folded over lower border is seen to project downwards, forwards and inwards. Behind the external process and shining through it is another dark spine-like structure (? embolus), and this is different in shape from what obtains in the other species.

Epigyne.—This resembles that of *C. grisea* in general plan, but is easily distinguished by its much greater breadth and by other details. The female of this species is quite recognisable.

This species belongs to a group of *Clubionæ* with very similar sexual organs. All of them have a trifold tibial apophysis with the inferior branch barbed. All have the pale external and dark internal apical palpal processes, and all have somewhat similar vulvæ.

This group contains five other species of which three, *C. reclusa* Camb., *C. grisea* L. Koch., and *C. subsultans* Thor., have already occurred in Britain. The other two are *C. Kulczynskii* de Lessert, and *C. interjecta* L. Koch., the former Swiss, and the latter Siberian. I have never seen either of these, but from the figures of Dr de Lessert and Professor Kulczynski, they cannot be confounded with the present species.

Clubiona humida occurs amongst moss and sphagnum in several swampy localities in Delamere forest. Up to now *C. grisea* L. Koch (*C. stagnatilis* Kulcz.) has not occurred there. The present species becomes adult in October, and some individuals survive the winter and can be found in the following spring.

EXPLANATION OF PLATE.

- | | |
|----------------------------------------|----------------------------------------------------------------------------------------------------------|
| 1. <i>Micryphantus nigripes</i> Sim. | Left palpus from outer side, showing lamella characteristic. |
| 2. " " | Lamella characteristic of left palpus from outer side and below. |
| 3. <i>Dismodicus elevatus</i> C. L. K. | Right palpal tibia from above. |
| 4. <i>Dismodicus bifrons</i> Bl. | Right palpal tibia from above. |
| 5. <i>Dismodicus elevatus</i> C. L. K. | Right palpal tibia from inner side and slightly above, showing external apical angle shown at <i>a</i> . |
| 6. <i>Dismodicus bifrons</i> Bl. | Right palpal tibia from inner side and slightly above, showing external apical angle shown at <i>a</i> . |
| 7. <i>Clubiona humida</i> sp. nov. | Left palpal tibia from above. |
| 8. " " " | The same from the outer side. |

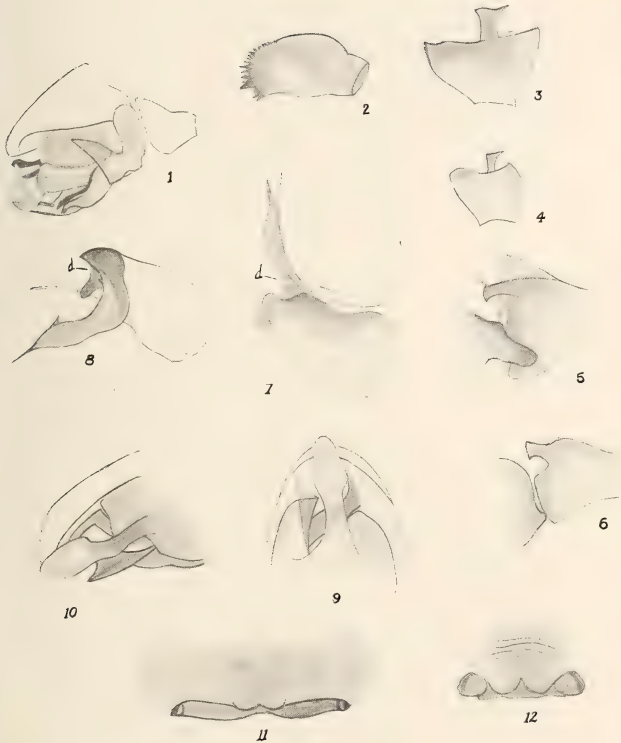
In Figs 7 and 8 *d* represents the extra branch of the tibial apophysis.

- | | |
|------------------------------------|----------------------------------------|
| 9. <i>Clubiona humida</i> sp. nov. | Apex of left palpal organs from below. |
| 10. " " " | The same from the outer side. |
| 11. " " " | Epigyne from below. |
| 12. <i>Clubiona grisea</i> L. K. | Epigyne from below. |

PLATE V.

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Royal Physical Society, Edinburgh.



SCOTTISH SPIDERS.

XXIV.—On a New Brachiate Asteroid Larva and on the Advanced Bipinnaria of *Luidia ciliaris* (Philippi) Gray. By James F. Gemmill, M.A., M.D., D.Sc.

(With Plate.)

(Read 21st December 1914. MS. received 25th January 1915.)

I. *Brachiolaria hibernica*, n. sp.

BRACHIA, stout, columnar, with very slightly convex ends, each of which carries about twenty papillæ; sucker much elongated transversely; a single row of six or seven papillæ to each side of the sucker; no papillæ on sides of brachia; ciliated processes cylindrical at extremities.

Locality of Occurrence.—50 miles N. by W. of Eagle Island, West of Ireland, taken in net drawn up from 1150 fathoms to surface.

Only one specimen of this highly interesting brachiolaria was obtained, but several *Luidia sarsi* bipinnariæ were caught in the same tow-netting, and probably all occurred relatively near the surface. It will be inferred from Pl. VI., Figs. 1 and 2, that the specimen is undergoing the retraction changes characteristic of early metamorphosis in larvæ with indirect development (see 6, pp. 251-253 and pls. xx. and xxi. figs. 12-14). We are not, therefore, in a position to speak definitely regarding the appearance of the uncontracted free-swimming larva, but in all probability it conformed to the type exemplified in the life-history of *Asterias rubens* L. (see 6, pls. xix., xx. figs. 10-12).

The retraction changes referred to above cause the preoral and middle regions of the larva to be drawn towards and finally incorporated with the left (future oral) aspect of the posterior or disc portion of the larval body. The mesenchymatous tissues of the regions undergoing shrinkage break down and are transferred in a semi-fluid condition to the disc, much of their debris being ultimately swallowed by the cells lining the hypoblastic tube, the wall of which becomes syncytial and greatly thickened. At the same time the larval mouth and anus undergo closure. Normally in the case of brachiate larvæ, prior to the changes in question, fixation has been effected, first (temporarily) by the brachia and afterwards (definitively) by the sucker. Sometimes, if larvæ have not the chance of attaching themselves, or fail to effect attachment, the retraction processes are nevertheless initiated. In such cases, normal metamorphosis does not appear to be possible in *A. rubens*, but according to Goto (8) it can readily occur in *A. vulgaris*. In our specimen

the retraction changes have progressed to near the stage shown in 6, pl. xxi. fig. 14 for *Asterias rubens*. The median brachium is almost opposite arm rudiment II, but the aboral brachiolarian notch, or space between arm rudiments I and II, is unduly great, probably because retraction was rendered imperfect by absence of fixation. The hydrocœle pouches (see explanation of Fig. 1) are near the stage shown for *A. rubens* in 6, pl. xxi. fig. 13, that is, they have as yet increased little in size and show no trace of out-pouchings for the first pair of sucker feet. There is also an unduly wide interval (oral brachiolarian notch) between hydrocœle pouches I and V, the first and last respectively of the series (see 6, p. 243).

The specimen was not sufficiently well preserved to allow satisfactory histological examination, and in particular nothing could be made out regarding the skeleton, but on cutting sections it appeared that the larval mouth and anus were closed, that the wall of the alimentary canal was greatly swollen, and that in general the arrangement of the enterocœlic cavities was comparable with that found in the *A. rubens* brachiolaria at a corresponding stage. Practically all the typical larval ciliated processes, namely, preoral, dorsal median, anterior dorsal, posterior dorsal, postero-lateral, and post-oral were still recognisable on one side or the other, and they appeared to be cylindrical, not flattened, at the extremities. The ciliated bands, however, could not be made out. The brachiolaria is remarkable for its size, measuring nearly 2 mm. across the disc, that is, more than twice as much as that of *A. rubens* at a corresponding stage.

At first the absence of mouth and anus, the general shape of the larva, its large size, and the possibility that it might come from a great depth, raised the question in my mind whether this was not a pelagic brachiolaria with abbreviated development, originating like the *Solaster* larva from a large yolky egg. Against this, it is to be noted that the characters of the brachia and sucker, the form and degree of development of the hydrocœle pouches, the width of the oral and aboral brachiolarian notches, the presence of remains of the various ciliated processes, the closure of the mouth and anus, and the thickened condition of the hypoblast lining, all make up just such a complex of characters as we expect to find in the early metamorphosis of feeding brachiolaria like those of *A. rubens* and *A. vulgaris*. On the whole, therefore, it seems in every way probable that our brachiolaria has been a feeding free-swimming one. Should the contrary by any chance prove true, we would have to infer that the yolky character of the eggs permitting direct development in this instance is an ever so much more recent acquirement than the similar condition in the eggs of *Asterina* (16), *Cribrella* (19), and *Solaster* (5).

OTHER DESCRIBED BRACHIOLARÆ WITH INDIRECT DEVELOPMENT.

1. Brachiolaria of *Asterias rubens*.—Brachia truncated, extremities carrying six to ten papillæ; sucker a round disc; two papillæ to each side of sucker; no papillæ on sides of arms; ciliated processes cylindrical (Mortensen 21, p. 42; Gemmill 6, pp. 235-237). The *Bipinnaria lævis* of Mortensen (21, p. 43), a larva described by Joh. Müller (24, 1848), in which the dorsal median process is absent, and there is sometimes a clump of papillæ on each side of the sucker, has been shown by me to be a variant form of the brachiolaria of *A. rubens* (see 6, p. 236).

2. Brachiolaria of *Asterias vulgaris*.—Practically same as that of *A. rubens* (Agassiz 1, pls. iii. and iv., but see also 6, p. 237).

3. Brachiolaria of *A. glacialis*.—Brachia markedly convex or bulbar at the extremities, each of which carries about fifteen separate papillæ; a circle of about fourteen small papillæ surrounding the sucker (Delage 3, pp. 36, 37).

4. Brachiolaria of *Porania pulvillus*.—Brachia convex at extremities; papillæ on extremities as well as on sides of brachia. Sucker, a round disc, with a row of about fifteen papillæ on each side of it extending between the median and the lateral brachia; dorsal median process reduced (Gemmill 7).

5. *Bipinnaria papillata*, Mortensen (21, p. 44) founded on Joh. Müller's description and figures (24, 1853, Taf. ix. figs. 9-12, *Brachiolaria of Messina*).—The parent form is unidentified. This brachiolaria has the ventral aspects of the brachia flattened and carrying nine or ten papillæ. The ends of the brachia are convex and carry several papillæ. There are also papillæ on each side of the sucker. The dorsal median process is well developed.

6. Reference may also be made to the unidentified *Bipinnaria megaloba* of Mortensen from the Sargasso Sea (21, p. 44). All the paired ciliated processes are broad and very long, almost as long as the body itself. The brachia were not fully developed in the specimen described, so that their final characters are unknown.

The principal attaching larvæ exhibiting direct development, with which we are acquainted at present, are *Cribrella oculata* (Sars 27, Masterman 19); *Asterias mülleri* (Sars 27); *Asterina gibbosa* (Ludwig 13, MacBride 16); Sp. unk. (Henderson 9); and *Solaster* (Gemmill 5). References to various other star-fish with yolky eggs and abbreviated development are given by Ludwig (15), Perrier (25), MacBride and Simpson (17), and Koehler (11), and Mortensen (23a).

II. The late larva of *Luidia ciliaris*.

In the next part of this paper is given for the first time a figure of the advanced bipinnaria of *L. ciliaris*, together with details regarding the number

and arrangement of its ciliated appendages, and records of its occurrence. Certain new data are added, having reference to the dorsal and ventral median lobes of this larva and to the ciliated appendages of the larva of *L. sarsi*.

The two species of *Luidia* which occur in British and western European seas (Sladen 28, p. 246) are *L. sarsi* Düben and Koren, and *L. ciliaris* (Philippi) Gray, the former having five arms and the latter seven. Both species have also a wide distribution within the Mediterranean (Ludwig 14).

We may take it as an ascertained fact that the *Bipinnaria asterigera* of Sars is the larva of the five-armed form *L. sarsi*. Descriptions and figures of advanced stages in this larva have been given by various authors, e.g., Sars (26), Koren and Danielssen (12), Joh. Müller (24, 1848, 1849), Mortensen (22), while Garstang (4) and M'Intosh (18) have described and figured what are in all probability intermediate stages in its larval history. Bury (2, pl. v. fig. 18) has figured a corresponding intermediate stage from the Mediterranean, but we cannot say for certain to which of the two his larva belongs.

In western European seas, the larva of *L. sarsi* with the star already developed is by no means infrequent (Mortensen 21, p. 39), and recently I had the opportunity of making over thirty records of its presence in Echinoderm plankton material sent me by the Department of Irish Fisheries, and dating chiefly from the years 1903-06. The case is altogether different with the *Bipinnaria asterigera* of the seven-rayed form, *L. ciliaris*. Apart from simple references to its occurrence in the Mediterranean [Metschnikoff 20 (a bipinnaria with seven-rayed star); Ludwig 14, p. 440], there appears to be only one notice of its capture, a single specimen having been taken by the Ingolf Expedition in summer 1895, latitude 61° 2' north, and longitude 40' east (Mortensen 21, p. 40). The specimen—a relatively large one—was identified by Ludwig, who concluded that it could not belong to any species except *L. ciliaris* (Mortensen *loc.*). The larva in question had been preserved in Flemming's solution, and was so much contracted that Mortensen was not able to make a proper drawing of it, or to determine the number of its ciliated appendages. He stated, however, that the dorsal and ventral median lobes or processes were of approximately equal length, and that both were simply rounded at their extremities—a contrast with *L. sarsi* in which the dorsal median lobe is much longer than the ventral one and ends in an expansion which is cordiform or heart-shaped, *i.e.*, showing a notch in the middle line anteriorly. Elsewhere (22, p. 10) he puts it as probable though not certain that the larva of *L. ciliaris* has a smaller number of ciliated appendages than that of *L. sarsi*, a "middle dorsal" process being present in the latter, but

probably not in the former. It will be seen from what follows that this conjecture is incorrect.

The plankton material from the Irish Fisheries Department, referred to above, included five¹ advanced larvæ of *L. ciliaris*, from one of which the accompanying figure (Fig. 3) has been drawn to scale. As regards the two median lobes or processes, the ventral median one is about three-quarters of the length of the dorsal median one, and the latter is very distinctly broadened at its extremity and shows a convex or rounded contour in the middle line anteriorly. The two lobes are bordered by their respective ciliated bands, which have become attenuated almost out of recognition. With reference to the ciliated appendages it will be remembered (Mortensen 21, p. 5) that, excluding the dorsal and ventral median processes, there are five ciliated processes on each side in the typical asteroid larva, namely, the preoral, the anterior dorsal, the posterior dorsal, the postero-lateral, and the post-oral, the first named being an extension of the preoral ciliated band and the remainder extensions of the post-oral ciliated band. However, it will be seen from Fig. 3 that in the bipinnaria of *L. ciliaris* there are not five but seven ciliated appendages in the neighbourhood of the mouth, and that of these

No. 1 is connected with the preoral band, and corresponds with the typical asteroid preoral ciliated process.

Nos. 2-7 are connected with the post-oral ciliated band, and have the following relations :—

Nos. 2 and 3 arise by a short common stalk nearly opposite to No. 1.

The corresponding pair in the larva of *L. sarsi* were considered by Mortensen to represent a deeply cleft anterior dorsal process (21, p. 38).

No. 4 arises close behind the stalk just named, and is still well in front of the angle of the mouth. The corresponding one in *L. sarsi* was termed by Mortensen the middle dorsal process (21, p. 38).

No. 5 arises behind the angle of the mouth and no doubt represents the typical posterior dorsal process.

¹ DATA OF RECORDS.

- 19.8.03. 30 miles W.N.W. of Tearaght Island, S.W. of Ireland, surface. (10, 1903, p. 70, Station S.R. 51.) One specimen with 11 pairs of sucker feet.
10.11.03. 50 miles W.N.W. of Tearaght Island, 50 fathoms. (10, 1903, p. 72, Station S.R. 65.) One specimen with 9 pairs of sucker feet.
3.11.05. 10 miles S.W. of Fastnet Rock, S.W. of Ireland, 26 fathoms. (10, 1905, p. 108, Station S.R. 267.) One specimen with 8 pairs of sucker feet.
11.8.10. 60 miles W. $\frac{1}{2}$ N. of Tearaght Island. (10, 1910, p. 180, Station S.R. 1001.) Two specimens with 12 and 9 pairs of sucker feet respectively.

No. 6 represents the postero-lateral process, and *is distinctly smaller on the left than on the right side.*

No. 7 represents the post-oral process, and is sometimes slightly smaller on the left than on the right side.

I very much doubt whether Mortensen's term "middle dorsal" process is strictly applicable to No. 4. The process in question clearly belongs to the anterior part of the larva, being well in front of the angle of the mouth, or region opposite to which the middle dorsal lobe or lappet is placed in the auricularian larva. While certainty on the matter will not be gained until the full development of the larva is known, it seems probable that Nos. 2, 3, and 4 are all subdivisions of the anterior dorsal process. Garstang's figure (4, pl. xxviii. figs. 1, 2) of an intermediate stage shows this process divided into two. Probably the posterior of the two divisions becomes our No. 4, while the anterior division again becomes subdivided to form Nos. 2 and 3. Bury's (2) similar larva from the Mediterranean has apparently only five ciliated processes on each side. More advanced but still relatively young *Luidia* (sp.?) bipinnariæ from Messina (kindly lent me by Dr Ashworth) all had the seven appendages just described, except in one instance where the first three were replaced on the right side by two short ones arising from a common base. Mortensen's work on the early development of *Luidia ciliaris* only brings us to the stage when the bases of outgrowth of the ciliated processes are becoming evident. In *Bipinnaria papillata* (Müller 24, 1853) we have an instance in which the posterior dorsal process is pressed backwards towards the postero-lateral, while the anterior dorsal process is exceptionally large and has a base of unusual breadth (Mortensen 21, p. 44).

Sars (26), and Koren and Danielssen (12) described the *Bipinnaria asterigera* (larva of *Luidia sarsi*) as having six ciliated appendages on each side in the neighbourhood of the mouth. Joh. Müller (24, 1848, 1849) counted seven, his figure showing that the first two on the dorsal aspect arise from a common stalk. Garstang (4), from an examination of his relatively early larvæ referred to above, believed Joh. Müller to be mistaken. Mortensen (21, pp. 38, 39) established the correctness of Müller's description and figures.

All the advanced bipinnariæ, both of *Luidia ciliaris* and *L. sarsi*, obtained by me in a condition suitable for examination exhibit a feature which does not seem to have been noted by any previous observer, namely, that the postero-lateral process on the left side is distinctly smaller than that on the right side, and indeed is occasionally little more than a short outfolding of the ciliated band. Not infrequently, also, the left post-oral process is

slightly smaller than the corresponding right one. In this connection it is interesting to note that Bury's figure of an intermediate *Bipinnaria asterigera* larva (2, pl. v. fig. 18) shows some reduction in size of the left postero-lateral and post-oral processes, particularly of the former. Shortening of the left postero-lateral is also a feature of Dr Ashworth's specimens referred to above.

The following measurements, etc., of the larva illustrated in Fig. 3 will be of interest:—

Total length of specimen	. . . . .	7.0 mm.
Centre of disc to tip of an arm	. . . . .	1.6 "
Length of preoral lobe from transverse portion of preoral band to bifurcation into ventral and dorsal median processes	. . . . .	3.5 "
Length of ventral median process	. . . . .	1.2 "
Breadth of " "	. . . . .	1.2 "
Length of dorsal median process	. . . . .	1.8 "
Breadth of " " near extremity	. . . . .	1.9 "
" " " near base	. . . . .	1.4 "
Length of the ciliated processes, <i>e.g.</i> , the posterior dorsals		2.0 "

Twelve pairs of sucker feet are present in each ray. A hump dorsally at the base of the dorsal median process probably marks the anterior limit of the anterior coelomic cavity.

I have to express indebtedness to the Irish Fisheries Department for the opportunity of examining the Echinoderm plankton material which contained the specimens described in this paper.

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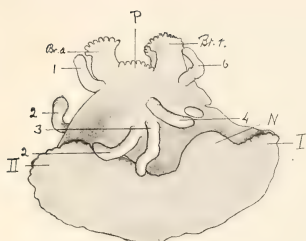


Fig. 2.



Fig. 1.

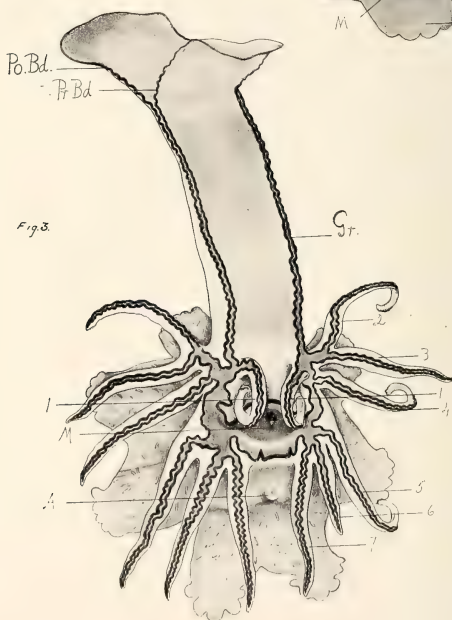


Fig. 3.

DESCRIPTION OF PLATE.

FIG. 1. View of *Brachiolaria hibernica* from left larval (future oral) aspect of disc portion of larva, into which the preoral lobe with sucker and brachia is being drawn. $\times 24$. The arm rudiments are indicated by Roman numerals, and the ciliated processes, now retracted, by ordinary numerals. The hydrocœle pouches are marked by crosses, pouch I being at this stage almost opposite arm rudiment II, and pouch V almost opposite interradius I/V. The great width of the oral and aboral brachiolarian notches, *i.e.* the spaces between arm rudiments I and II and between hydrocœle pouches I and V, will accordingly be noted. N is placed on a prominence of soft tissues in the aboral notch. M indicates the former position of the mouth opening.

FIG. 2. View of same larva from right side but tilted over, showing the brachia in profile view. $\times 24$. The remains of the larval ciliated processes are seen better than in Fig. 1. The post-oral process is the one most reduced.

Lettering in Figs. 1 and 2.

- I, II, III, The aboral arm rudiments numbered according to scheme explained in 6, etc. p. 276.
 1, 2, 3, 4, 6 The remains of the larval ciliated processes in the following sequence:—dorsal median, anterior dorsal, posterior dorsal, postero-lateral, and preoral.
 +, + Position of the hydrocœle pouches.
Br.a., *Br.l.*, *Br.r.* The anterior, left and right brachia respectively.
M Remains of larval mouth.
N Temporary prominence of soft tissues in the brachiolarian notch.

FIG. 3. View of advanced larva of *Luidia ciliaris* from ventral aspect. $\times 18$. The broadening at the anterior end of the dorsal median lobe is in certain states of contraction relatively greater than here indicated.

Lettering in Fig. 3.

- 1, 2, 3, etc. The various larval ciliated appendages (see explanation in text).
A Anus.
Gr. Groove between the preoral and post-oral ciliated bands.
M. Mouth.
Po.Bd. and *Pr.Bd.* The post-oral and preoral ciliated bands respectively.

XXV.—Notes on the Habits of the Rhea. By A. Pride. (Communicated by Professor J. Graham Kerr, F.R.S.).

(Read 22nd February 1915. MS. received 22nd February 1915.)

At the beginning of April, in the Paraguayan Chaco, the Rhea begins to boom, an indication that the mating season has commenced. To effect the boom the male bird draws himself up to his full height, ruffles out his neck feathers and, with beak closed, apparently sends the sound through his nostrils. The "boom" when heard close to the bird sounds ridiculously small and weak compared with its effect at a distance.

The appearance of the Pleiades in the middle of June, just before day-break, is the sign which guides the Indian in his expectation of Rheas' eggs. The announcement of the constellation is usually accompanied with the information, "we shall soon have Rhea eggs now." But early in May I have taken the eggs, and as late as December they have been brought to me; but at the latter time one must beware of their condition. Ten eggs in a nest is a very usual number; the largest number I have seen taken was twenty-seven. These were all put together by the Indian who found them and cooked in a big pot, but a report like a small cannon announced that one at least had "failed." One of the greatest enemies of the Rhea's nest is the black-maned wolf which wanders solitary over the country, and which, finding a nest, puts the parent bird on the unemployed list for the rest of the season.

The parent bird has various calls to its chicks to warn them of danger. When they are very small he utters one which causes them to take up prone positions on the ground with their little necks stretched out. Their coloration at this stage is almost the same as that of a "partridge" (tinamou), and as long as they lie quiet they are very difficult to detect. They seem incapable however of so remaining, and soon begin to whine for the parent, which has run off. The monotonous whine is synchronous with the downy stage of the chick and ceases when the feathers appear. When kept in captivity the chicks are interesting little creatures as they go whining round the sides of the house stalking flies and mosquitoes on the wall. Even when their stalk is successful a jubilant note never replaces the petulant dissatisfied whine. During the first few months of their lives the birds consume an enormous amount of dirt and small lumps of sun-baked clay, doubtlessly case-hardening their stomachs for future years, when they swallow prickly pears whole and suffer no irritation from the spines.

A second call of the parent appears to give warning of danger from above. This sound can be well represented by keeping the lips apart and allowing the tongue and lips to vibrate as the breath is violently expelled. Upon hearing the sound, the young birds feeding in the vicinity of the parent flock together, every head being tilted upward to see from where and from what the danger proceeds. At the same time the wings are somewhat outspread, and the few white plumes upon them droop toward the ground; the body of the bird by this process appearing almost twice its usual size. I found this cry very useful with a small flock of young birds I once had. Indians would carelessly leave the gate to my vegetable garden open, and the flock would get in and sample the salads. The easiest and quickest way to get them out was for me to stand imitating this cry at the gate, and when I had got them bunched together to retire from the garden continually crying. Invariably the birds followed me, all on the watch for danger above.

A third cry is a low whistle which causes every young bird to stop eating, stand erect, and look across the country.

I found the young birds to dwell in unity with each other; but when the males were a year old they showed signs of pugnacity, and in the second year, during the mating season, one bird attacked anything—man or beast. Excessive gambolling on their part in the early morning was as sure a sign of an approaching change of weather as a falling barometer. They invariably dusted themselves before settling down to sleep, and at sundown after a very hot day they would stand in the shade, spread out their wings to their fullest extent, and raise every feather on their body. Adult birds in their natural state behave in a similar way, and at such a time seem to be very stupid and not so alert, since they allow one to get within easy range of them. In a blazing midday sun they feed out in the open unaffected by the heat, but in the evening they apparently feel the necessity to cool down and are less wary.

Their method of attack upon a small animal was shown one day when I found my biggest bird trying to knock the life out of a small kid. Its method was to rush over the kid with all its plumes drooping, the white ones quite concealing the legs, then having knocked the kid down, to seize it by the nape of the neck and throw it over. My birds usually accompanied the flock of goats and sheep when they went to pasture, but this particular Rhea, apparently finding the kid alone, and perhaps failing to recognise the species, or thinking it would be a harmless specimen to practise an attack upon, did so, and persisted until I was satisfied as to its attacking tactics and drove it off.

The sense of locality or homing is well developed in the Rhea. After a sojourn of two years with me my biggest bird took a fortnight's holiday, and I thought he had disappeared. I may say that all the time I had them they were unrestrained by fences, having the whole country-side at their disposal. At the end of the fortnight he returned with a portion of a wooden arrow sticking in his thigh, and after it was taken out he remained at home until he was quite well again. In a short time he took another holiday of about the same duration as the first, and again he came limping back to hospital with a gun-shot wound in the knee. Thereafter he seemed content to stay at home and return each night. During these absences he must have wandered far away, for I was frequently abroad in the country and during these journeys never saw any trace of him.

The Indian's method of hunting the Rhea is worth recording. Experience has taught him that the wily bird, with its long outstretched neck and keen eye whereby it can survey the wide stretches of open country over which it roams, is more than a match for him. Accordingly he has met wariness with guile. Armed with his bow and wooden, barbed arrows, he starts out from his little grass hut in the early morn, inspired, should a north wind be blowing, by greater hopes of success. At the first coppice or wood he chops from a bush about half-a-dozen light branches about three or four feet in length. These he loosely binds together at the cut ends and proceeds to intertwine with them small lianas. Smaller and lighter twigs are then tied to the longer ones, the leafy parts pointing upward. When the whole is finished to his satisfaction he places the construction upon his shoulders. The longer branches and lianas hang down into the long grass, the smaller twigs conceal his head, and the whole effect of his capé of verdure is to convert him into a walking bush. Upon sighting a bird he stands perfectly still, if its head should be erected, and, as soon as it lowers it to feed he hurries forward, again halting as soon as its head and neck appear above the grass. In this manner he can approach within bow-shot of the bird. Great care and patience are necessary in the final approach, but the Indian is well equipped in both respects.

How excellent the disguise is the following incident will show. One of the tame birds above-mentioned was one day feeding in the open in front of my house, about a mile away. An Indian who was out hunting under the "bush" disguise was seen to be stalking it, having taken it for a wild bird; for these often came within a short distance of the house. As he carefully, almost imperceptibly, approached, the bird went towards him, being actually attracted to the disguise by some white flowers upon it of which the birds are very fond. Fortunately the Indian recognised the bird in time and spared

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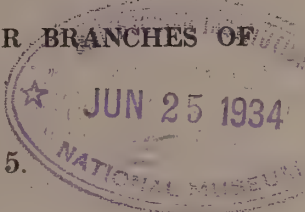
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its life. On another occasion when I was travelling with a party of Indians over an open plain a deer was sighted, and one of the men took a long shot at it with his arrow, and missed. A moment or two afterwards I heard a little commotion behind, and upon looking round found the party had increased by one and he was carrying this branch disguise in his hand. Though there were six of us we had all passed within a few yards of him and not noticed more than a bush in the plain. He, poor fellow, had been stalking the deer, and we had spoiled his supper, but he had the laugh at us for having all blindly passed him by.

Another method of hunting the bird, but one not often used, is for the Indian, upon sighting a bird, to throw his large blanket over his head and outstretched arms, and in the most approved ghost method to wave his blanket vigorously up and down. The bird upon seeing him shows every indication of anger and comes boldly to attack him, only to fall before a well-aimed arrow or gun shot.

The meat of the Rhea is much liked by the Indian, and indeed is very palatable, but a foreigner must be careful, for between the sheathing of the muscles long wire-like worms (Nematodes) are often found. The Indians sell the feathers, and they are made into fine feather dusters for valuable china and pictures. The bird's skin is taken off whole, and this is the perquisite of the woman, who, after inflating it, dries it in the sun, softens it, and uses it in the same way that her more civilised sister uses a chest of drawers.

(Issued separately, 16th May 1915.)

XXVI.—The Cyst of *Amoeba proteus*. By Lucy Agnes Carter, S.N.D.,
B.Sc., Strang Steel Scholar, Glasgow University.

(With Plate.)

(Read 22nd February 1915. MS. received 22nd February 1915.)

INTRODUCTION.

WORK on the various types of amoebæ, both free-living and parasitic, proceeds apace, and as each life-history reveals itself, the hope that the complete life-cycle of one of our largest free-living types, *A. proteus*, may soon be added to the already long and interesting list, increases as the smaller species are eliminated from the field.

The only recorded work on the encystment of *A. proteus*, available up to the present time, is a paper by Scheel, which appeared in the *Festschrift Carl von Kupffer*, 1899. The author preludes his article with a short note of the work done by previous writers on reproduction in the amoeba group; this dispenses with the necessity for any such summary here.

The cyst about to be described corresponds very well in size and outward appearance to that studied by Scheel, but there are palpable differences. Owing to the fact that Scheel has figured no stage of the cyst until the secondary nuclei are formed and the young amoebæ are about to be cut off from the protoplasmic matrix, it is difficult, in face of these differences, to decide whether the cysts are the same or not.

MATERIAL.

The cysts were found during two successive winters in material supplied every second day by Mr T. Bolton of Birmingham, from a pond which for three years has yielded no large amoebæ other than *A. proteus*. The material used in an earlier paper¹ was obtained from the same source.

Although the amoebæ encysted when left undisturbed in the Petri-dishes into which the incoming supplies were severally put, they never did so when isolated in any kind of artificial culture medium.

The first appearance of cysts was in February 1912. As some of these were already well developed, the amoebæ must have encysted much earlier; this was found to be the case the following year. The months

¹ Carter, "Note on a Case of Mitotic Division in *A. proteus*," *Proc. Roy. Phys. Soc. Edin.*, vol. xix., No. 4, p. 54, 1913.

during which encystment naturally takes place appear to be January and February, subject no doubt to fluctuations from late December to the middle of March, according to the severity of the winter, although from experiments tried it would seem that cold is not by any means the most important factor in the process of encystment.

APPEARANCE OF CYST.

All that Scheel said of the external appearance of the amoeban cyst upon which he worked may also be said of the one here described.

The cyst is spherical in form, and has no means or method of attachment. Its outer surface is covered so completely with plant détrit^{us}, diatoms, etc., that in life only the outline of the internal contents can be seen; occasionally, however, if the débris is of a light character, the granular protoplasm and the nucleus can just be discerned in the early cyst. Scheel mentions this outer covering, but does not show it in any of his drawings. In transmitted light the amoeba-body shines as a silvery mass through the "glassy zone" and rough débris.

In no case has a group of cysts been found, as figured by Scheel, in one enveloping outer wall. The cysts do occasionally cling together by their outer coating of débris, but this in no way interferes with their individual constitution.

ENCYSTMENT OF THE AMOEBA.

When about to encyst, the amoeba, which at this time is usually very well fed with diatoms and other organisms, becomes heavy in appearance and sluggish in its movements. A slimy mucous substance is exuded by the slowly moving creature which causes the diatoms, other small organisms and plant remains occurring in its path to adhere to the outer surface of the protoplasm. In fact this exudation, whatever it may be, makes the touching of the amoeba at this time a very difficult task. When the animal is in its normal condition, it is quite an easy matter to move it about by means of a seeker or fine blunt needle, without the least risk of injury; but when the slime is covering the surface, a seeker placed on the amoeba is soon smeared with the exudation, and the protoplasm of the specimen touched clings to it in such a way as to cause the disruption, if not the death, of the creature when an attempt is made to withdraw the instrument.

The amoeba casts off all waste products, such as diatom-shells and

undigested food material, before the final encystment, and this adds to the débris already gathered from the surrounding water.

Nestling then in this mass of débris so collected and ejected, the amoeba appears in transmitted light as a silvery grey mass, irregular in outline, with its protective wall as described; the irregularity soon disappears, and the form of the outer covering as well as the internal contents become spherical (Pl. VII. Fig. 1). At first, if such a mass be teased slightly with a needle, the amoeba will creep out and slowly attempt to push out blunt pseudopodia—but will make every effort possible, in its heavy condition, to return to the débris. If, however, the spherical form is well established then a push with the needle will send the whole cyst, as it can now be called, rolling out from the débris, and its individual form can be well seen.

To obtain the amoeba, a careful tear can be made in the outer envelope by means of two needles, then a little gentle pressure on the wall opposite to the opening made will cause the now spherical amoeba to roll out. Only in one or two cases has the creature been seen, when this stage has been reached, to make any attempt to assume its own free irregular form or to put out pseudopodia. If so turned out, the amoeba remains inactive and degenerates.

No rotating movement, as described by Scheel, has been seen during the encystment of the amoeba, but several times a ciliate has been observed to enter into a temporary cyst and show rotation within it after a manner answering to his description, the cilia working rapidly the whole time. It is a very deceptive process, especially as the ciliate is normally filled with refractive bodies—probably reserve food material.

This ciliate will remain some time in the temporarily encysted condition, but a little irritation soon causes it to return to its original form and swim through the water again. As, however, the organism never covers itself with débris for this purpose, the absence of such débris is a good criterion by which to judge whether a given cyst belongs to the ciliate.

There is danger of confusion, however, with a temporarily encysted rotifer, which does so cover itself, and moreover produces a cyst in shape and size identical with the cyst of *A. proteus*, so that much trouble and sometimes not a little difficulty in distinguishing the two arises. This difficulty increases as the amoeba cyst ripens, since it then becomes as transparent as that of the rotifer. This in life; when fixed and stained in eosin, preparatory to sectioning, it also seems impossible to distinguish the cysts; but when they are sectioned the difficulty naturally disappears.

Some attempts made by *A. proteus* to encyst without the protection of débris have been observed, but they were not a complete success; hence the

following description of the living cyst is based upon optical sections, through the débris, after as much as possible of this has been removed.

The walls of the cyst are three in number, if the outer envelope of débris be included in the term "wall." There is little doubt but that its constituents are cemented together by the exudation from the amoeba while encysting, and it is thus a part-product of the creature for self-defence and not an accident. Whether this first formed wall would occur if the amoeba could be induced to encyst in the absence of débris, I have not been able to prove satisfactorily up to the present. The two remaining, or rather the true walls, of the cyst are membranous, the outer being the older. In the earlier stages these two walls are spherical and well filled by the amoeba-body, but as maturity is reached there is usually a contraction of the protoplasm within the younger membrane.

There is no reason for assuming that the space between the older membrane and the outer envelope is occupied by anything more than a watery fluid—that is to say—there is no thick hyaline wall, as described by Scheel in the case of the cyst studied by him, and termed the "glassy zone."

When an encysted amoeba was turned out of its envelope of débris, it became clear that the older membrane was quite free from this wall by the way in which the spherical amoeba rolled out, and moreover, if the two membranous walls were complete, a second pricking combined with delicate pressure would set the amoeba with its youngest wall quite free from the outer, and in no case were there visible the jagged edges of anything other than a fine membrane.

With regard to the internal contents, as has been already mentioned, the granular protoplasm and the form of the nucleus can sometimes be seen, but when the early stage is passed nothing can be distinguished. A ripe cyst has more than once been fixed and sectioned which showed no features to mark it off from the empty cysts by which it was surrounded, so transparent had its contents become.

In size the cysts agree with Scheel's measurements, averaging in life from 70 μ to 140 μ in diameter, but after fixation the contraction leaves the sectioned cysts from 60 μ to 110 μ in diameter.

METHOD.

The material when received from the pond was carefully examined for cysts. If any were found they were isolated from the stock, which was then left undisturbed for several days to favour the encystment of any unencysted amoebæ, many of which were always present. Of the isolated

cysts definite numbers were taken and fixed on different dates. If more cysts were afterwards found in the "stock" which had been set apart, they too were isolated. By this means a great number of "stock" Petri-dishes and watch-glasses containing the isolated cysts were soon collected and experiments tried for initial encystment in the case of the amoebæ from the "stocks," and for continuance of development in the encysting and encysted amoebæ, with varying success.

FIXATION AND STAINING.

In 1912 the cysts were fixed in corrosive acetic 10-20 minutes, in 1913 in corrosive alcohol from 45-60 minutes. The shrinkage seems greater in the latter, the outer membranous wall collapsing more readily.

After fixation they were passed through the alcohols 30 % - 90 % + eosin (to render them conspicuous after clearing in clove oil); absolute alcohol, 24 hours in each; clove oil, 24 hours; clove oil and celloidin, 8 days; chloroform, 3 hours; paraffin (52° C.), 15 minutes. All the sections were cut 5 μ in thickness.

The sections were stained in Ehrlich's hæmatoxylin, but after examination this stain was replaced by iron hæmatoxylin except in the case of the sections shown in Pl. VII. Figs. 3 and 4.

As the nucleus breaks down a change seems to occur in the constitution of the protoplasm of the amoeba-body. A similar change has been observed by Popoff¹ in his study of *A. minuta*. This protoplasm now becomes strongly stainable. When the stain employed is borax carmine, or Ehrlich's hæmatoxylin, the nucleus still holds its ascendancy, though not great (Fig. 3); but if iron hæmatoxylin has been used then the nucleus parts with the stain almost immediately when placed in iron-alum solution while its surroundings are still quite black.

In one case a nucleus similar in condition to that shown in Fig. 4 (N) was left in this iron hæmatoxylin stain for 36 hours, but on being placed in the alum solution parted with the stain in less than 5 minutes. Apparently the property gained by the protoplasm is lost by the nucleus.

The plastin, or whatever complex of plastin and chromatin it may be which is passed from the nucleus (Pl. VII, Figs. 4, 5, 6), is most tenacious of all stains—a brilliant red in borax carmine, a deep blue in Ehrlich, and black, after a very lengthy destaining process, in iron hæmatoxylin.

The nuclear membrane can still be seen during the breaking down of the nucleus. It finally disappears with the rest of the degenerated portion.

¹ Popoff, "*A. minuta*," *Archiv für Protistenkunde*, Bd. 22, p. 202, 1911.

Attempts to stain intra-vitam produced little or no effect. The pores in the cyst walls mentioned by Scheel have not been observed.

CONTENTS OF THE CYSTS AS SEEN IN SECTIONS.

The outer envelope of débris, small stones, etc., shows up very well in the sections, always maintaining its spherical or oval form, while the inner membranous walls collapse as a rule.

The tenacity of this outer envelope seems to confirm the idea that its constituents are cemented together by the slimy exudation already referred to.

Thus the combined study of the process of encystment, as seen in life and in the sectioned cysts, leads one to conclude that after the cementing of the débris the amoeba-body withdraws itself from its protective envelope, and rounding itself off forms its outer membranous wall. After this a slight contraction of the protoplasm as it concentrates, and the formation of the second membranous wall, completes the protection of the now encysted amoeba.

As the cyst ripens the membranous walls contract and crumple round about the amoeba-body, while, as mentioned earlier, the wall of débris remains intact until the young amoebæ are ready to escape (Pl. VII. Fig. 9). The period of encystment lasts from 10 to 12 weeks.

THE NUCLEUS.

The nucleus breaks down; the chromatin and plastin are distributed throughout the cytoplasm, and secondary nuclei are formed. These secondary nuclei are of the protokaryon type, showing a relatively large karyosome slung up in the nuclear sap by achromatic radiating fibres, each terminating in a chromatin granule similar in all appearance to the karyosome but retaining the stain less intensely (Fig. 9a). No membrane has been distinguished at this stage. These secondary nuclei resemble that shown by Gläser¹ for *A. tachypodia*. Described on the alveolar theory the achromatic fibres become the lines of demarcation between the alveoli in the secondary nucleus, but the absence here of a membrane presents a little difficulty.

THE DIFFERENTIATION OF THE YOUNG AMOEBÆ.

The nuclei now cut off portions of the cytoplasm forming the young amoebæ—not in this case the numbers mentioned by Scheel, 500 to

¹ Gläser, "*A. tachypodia*," *Archiv für Protistenkunde*, Bd. 25, p. 27, 1912

600—but from 75 to 100 in the cysts where they could be counted in the sections.

There seems to be no strict order for their formation—many are already free in the central portion, while near the margin some are not yet cut off (Pl. VII. Fig. 8 *sa'*). In other specimens (cf. Fig. 9) the central portion still contains protoplasm not yet apportioned to its nuclei.

A young amoeba (Fig. 9a) from the cyst, a section of which is shown in Fig. 9, is drawn to a larger scale, together with one of the secondary nuclei, 7a from Fig. 7, to the same scale.

Until *A. proteus* can be induced to encyst in pure cultures without débris, the question of the young amoebæ freed from the cyst must remain an open one, as amoeboid organisms of similar appearance turn up in any culture in which plant débris is present, since material of this nature is always liable to contain organisms which have an amoeboid phase in their life-history—to say nothing of the great variety of small amoebæ which live and multiply in such cultures.

However, time after time, I have found free among the ripe cysts, young amoebæ possessing blunt pseudopodia and a vesicular nucleus similar to that possessed by the amoebæ just being liberated from the cyst (cf. Fig. 9a). These increased in size, too, for some days, but I was unable to keep them alive, under artificial conditions, for the length of time necessary to prove beyond a doubt that they were true *A. proteus*, and from that confidently to state that they originated from the cysts with which they were found.

There are four points which Scheel puts forward as the conclusions to be drawn from his investigation. A statement of these, together with the results here obtained, will show in what the cysts described by him agree, and in what they differ, from those observed by myself.

In size, outward appearance—except for the grouped cysts—and length of encysting period, $2\frac{1}{2}$ to 3 months, the two types are practically identical, but they differ upon the very important point of the behaviour of the nucleus. The four points referred to are as follows:—

1. Bei *Amoeba proteus* tritt ausser der gewöhnlichen Zweiteilung zu gewissen Zeiten ein multipler Vermehrungsprocess auf, welcher sich innerhalb einer vom Tier selbst ausgeschiedenen Hüll abspielt.

2. Der Nucleus der encystierten Amöbe zerfällt durch successive direkte Teilung in eine grosse Anzahl von Tochterkernen, Enkelkernen usw.

3. Der Amöbenkörper zerfällt, wenn die Zahl der Kerne auf 500-600 gestiegen ist, in ebenso viele sich gegeneinander abgrenzende Tochterindividuen, welche durch Zerfall der Hülle frei werden.

4. Ein Flagellatenstadium tritt bei *Amoeba proteus* nicht auf. Die Sprösslinge gehen direkt in das Amöbenstadium über.

That *A. proteus* divides by the ordinary twofold division is now an established fact; but that the multi-nucleated form, which itself divides by direct division—and probably also undergoes fragmentation—is identical with the uninucleate form of *A. proteus* still remains to be demonstrated.

Scheel figures the nuclei in the cyst in various stages of division—and by this shows that the nucleus of the encysted amoeba does not break down, as stated in this paper, but divides throughout by direct division. Again, as I have mentioned, the number of small amoeba produced in the cysts observed by myself is not more than one-fifth of the number shown by him.

Finally Scheel's observation that *Amoeba proteus* passes through no flagellate phase in its life-history agrees with the conclusions reached in this short paper.

That there may be two types of cysts in *A. proteus*, as Popoff¹ has shown to be the case for *A. minuta*, seems quite possible and not at all improbable to one who has studied the various amoebæ which lay claim to the name *A. proteus* at the present day, but we have still to discover (*a*) the second cyst similar to Scheel's if it exists, and (*b*) the stages connecting it to the type of cyst described in this paper.

This work has been carried on partly at the Zoological Department, Glasgow University, under the supervision of Professor Graham Kerr, and partly at the College of Notre Dame, Dowanhill. I am much indebted to former lecturers in Protozoology at the University—Mr C. H. Martin and Mr J. Dunkerly—for their kind criticism and encouragement throughout.

¹ *Loc. cit.*

DESCRIPTION OF FIGURES.

All figures drawn with aid of an Abbé camera.

Figures 1 and 2. Optical sections from life—Zeiss oc. 4, obj. D.

Figures 3, 4, 5, 6, 7, 8, 9. From stained sections $5\ \mu$ in thickness—Zeiss oc. 2.
Leitz oil immersion $\frac{1}{12}$ inch.

Figures 7A, 9A. Zeiss oc. 12. Leitz oil immersion $\frac{1}{12}$ inch.

The ages of the cyst stages figured from sections are approximately as follows, reckoning from time of encystment—

Fig. 3	about 10 days.	Fig. 7	about 6 weeks.
" 4	" 14 "	" 8	" 8 "
Figs. 5 and 6	" 21 "	" 9	" 10 "

From Life.

Fig. 1. An amoeba just rounded off in nest of débris

" 2. " " in completely formed cyst.

From Sections.

Fig. 3. Breaking down of nucleus.

" 4. Passing of plastin? from nucleus (*pl.*). Shows 1st membranous wall (*b*).

" 5. Chromidia throughout cytoplasm. Stain no longer held by nucleus. Wall (*c*) does not show in this cyst.

" 6. Showing the remains or rather the degenerating matrix of the nucleus, and again the torn outer membrane.

" 7. The appearance of the secondary nuclei. The outer walls are not shown in this section.

" 7A. Two of the secondary nuclei drawn to a larger scale, showing in one case the centriole, which may be seen occasionally in some of these small nuclei.

" 8. The apportioning of the protoplasm to the secondary nuclei. Some amoebæ not yet free at margin (*sa'*).

" 9. The small amoebæ being set free into the cyst cavity, but not yet to exterior. Some amoebæ (*sa'*) not yet free in the central portion.

" 9A. Small amoeba from another section of cyst 9 above, showing pseudopodia, nucleus (cf. 7A).

Letter References.

a. Outer wall of débris.

b. 1st membranous wall.

c. 2nd membranous wall.

P. Protoplasm of amoeba-body.

N. Nucleus of encysted amoeba.

n. Secondary nucleus.

ch. Chromidia.

pl. Plastin or plastin-chromatin complex.

sa. Small amoebæ product of encystment.

sa'. " " not yet completely defined.

Nm. Nuclear membrane.

PLATE VII.

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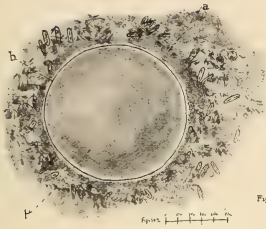


Fig. 1

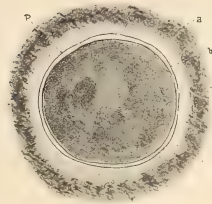


Fig. 2.

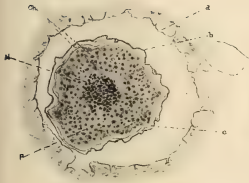


Fig. 3

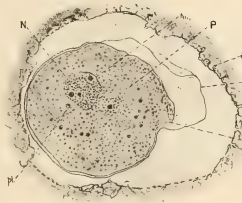


Fig. 4



Fig. 5.

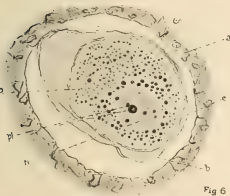


Fig. 6



Fig. 7a.

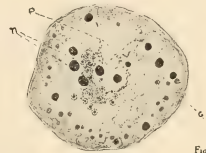


Fig. 7

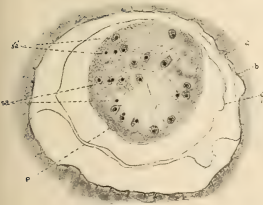


Fig. 8.

Scale for Figs 3-9.



Fig. 9a



Fig. 9.

L. A. C. del.

ENCYSTMENT OF AMOEBA PROTEUS.

XXVII.—*Agarella gracilis*, a new genus and species of Myxosporidian, parasitic in *Lepidosiren paradoxa*. By J. S. Dunkerly, B.Sc., Glasgow University.

(With Plate.)

(Read 22nd February 1915. MS. received 22nd February 1915.)

IN the course of his work [1] on the spermatogenesis of *Lepidosiren paradoxa*, the South American lung-fish, Dr W. E. Agar discovered certain bodies in the testis which he took to be parasitic Protozoa. He was good enough to give me the opportunity of examining these bodies, and to this end he not only allowed me the use of his mounted smears and sections of testes but supplied me freely with further material collected and preserved by him, and I am glad to take this opportunity of thanking him for his kindness in this matter.

I had completed a description of this parasite, and the MS. and drawings were sent to Germany on the 25th July last for publication in *Archiv für Protistenkunde*, but as war was declared between England and Germany on 4th August, there is little chance of my paper being available in that journal for some time to come. The following account, therefore, is a slightly abbreviated account of the work, together with drawings of the more important stages.

The parasite is a Myxosporidian belonging to the family Chloromyxidæ, and was studied by means of sections and smears of testis. The smears were especially useful, and had been fixed with corrosive acetic mixture and stained with Delafield's hæmatoxylin by Dr Agar. Some of these I unmounted and restained with iron-alum hæmatoxylin, and the different aspects presented by the two methods of staining have a certain amount of interest.

As regards the name and systematic position of this form, the spores (Pl. VIII. Fig. 12) differ from those of the genus *Chloromyxum* in being elongate, slightly flattened in the sutural plane, and in possessing a long bifid tail composed of an elongation of each spore valve posteriorly. The form of the spore, therefore, exactly resembles that of *Henneguya*, from which it differs, however, in possessing four polar capsules—the characteristic mark of members of the family Chloromyxidæ. Thélohan [13] described a species of *Chloromyxum* (*C. caudatum*) with an "appendice posterieure . . . comme chez les *Henneguya* parfois bifurqué," but its proportions and form are different from those of a typical *Henneguya*, and from those of the form described in this present paper. It resembles more a *Chloromyxum* with a well-developed tuft of hairlike processes posteriorly, such as *Chloromyxum leydigii* often shows.

There is no doubt, however, that the present form is as distinct from *Chloromyxum* as *Henneguya* is from *Myxobolus*, and I therefore propose to give it the name of *Agarella* ¹ *gracilis* **gen. et sp. nov.**, and the family Chloromyxidæ will contain at present two genera, *Chloromyxum* and *Agarella*. Doflein [5] long ago suggested that "eine Parallelreihe mit je vier Polkapseln zu jenen Formen mit je zwei Polkapseln existiert," although "alle Typen sind zwar noch nicht gefunden worden," and in this sense *Henneguya* and *Agarella* are parallel forms, the former with two, and the latter with four, polar capsules.

Most of the Chloromyxidæ, including Thélohan's *C. caudatum* mentioned above, are parasites of the gall bladder either of fishes or of reptiles. In view of the peculiarly primitive characters of the Dipnoi, it is interesting to note that the only two species of Chloromyxidæ described from tissues, with the exception of a problematical form described by Tyzzer as forming cysts in the muscles of fish, are *Chloromyxum proteus* Joseph from the kidney tubules of the Amphibian *Proteus anguineus* from Carniola and *Agarella gracilis* mihi, from the testis-follicles of the Dipnoan *Lepidosiren paradoxa* from S. America. Far too little is known, however, of the distribution and occurrence of the Chloromyxidæ to permit us to draw any conclusions from this fact.

The mature spores are seen in the cyst in Fig. 1, but in every section of an infected testis they are quite numerous also in the pigment (?) cells which occur in the capsule of the testis. These pigment-cells may be found, though rarely, in the testis-follicles, as was pointed out to me first by Dr Agar, and they apparently collect the adult spores, presumably after rupture of the cyst wall. Certainly the spores contained within such pigment-cells show signs of nuclear degeneration, and perhaps one of the functions of these pigment-cells may be that of collecting foreign and waste bodies from the testis-follicles; but they are never found in blood capillaries, and are peculiar apparently to the testis tissue.

It is, however, by the study of smear preparations that the development of the sporoblast is best followed, as Thélohan [13] long ago pointed out, owing to the fact that the cyst or plasmodium is burst by the operation of smearing and the individual pansporoblasts are thus isolated. The following account of the spore development is based, therefore, on smear preparations only.

Auerbach [2 and 3], in his papers on Myxosporidia of Norwegian fish, has given the best and most connected account of the spore development in this group, and, according to him, the first stage is the formation of macro- and micro-gametes from macro- and micro-gametocytes. The next step is "je ein Macro- und Micro- gameten copulieren," and in the cases where a synkaryon

¹ After Dr Agar who collected the material on which the description is based.

is formed only at the end of the spore development, "in der Copula findet jedoch eine Kernverschmelzung nicht statt, vielmehr teilen sich die Kerne weiter bis die Zahl von 8 (monosporer Typ) oder 14 (disporer Typ) erreicht ist [2, p. 205].

Now as to the formation of the "gametes" I have no new evidence to offer, but certain figures seen by me in the developing spores of *Agarella gracilis* seem to indicate another method of origin of the pansporoblast (disporous type). The presence of large and small cells, Auerbach's macro- and micro- gametes, which copulate is certain (Pl. VIII. Fig. 5); but one can find also such unions as those depicted in Figs. 6 and 7, which would indicate further fusion of such copulæ in pairs.

A description of the figures seen in smears will be given first, and in this description certain interpretations will be given to the various stages. As these lead to a method of regarding the Myxosporidian pansporoblast which differs from that of recent authors, notably Auerbach and Georgevitch [6], the reasons for the interpretations here given will be discussed afterwards.

According to Auerbach and others the macro- and micro- gametes are formed by division of macro- and micro- gametocytes, and the same is true for *Agarella gracilis*, but as there is nothing new here the first stages which concern us (Pl. VIII. Figs. 2-4) are the macro- and micro- gametes of Auerbach and others, while Fig. 5 represents the union of these two cells. Nothing resembling Mercier's description of the formation of a synkaryon at this stage was seen. Now Pl. VIII. Figs. 6 and 7 represent stages which can be interpreted most naturally as the fusion of two such cells as Fig. 5, while Fig. 8 shows the resulting cell or syncytium with four nuclei derived from four different cells. Support is lent to this interpretation of the figures by the fact that the size of the developing pansporoblast (Fig. 9) is much nearer that of two united sporoblasts than it is to that of a single sporoblast. (Fig. 5 shows an unusually large sporoblast.) From this point onwards the pansporoblast, as it is now called, proceeds as usual by repeated nuclear divisions to form the complex arrangement of two spores into which it is transformed finally. The fate of the two small nuclei during this process would be a point of some importance, but it is difficult to be certain in this matter, owing to the fact that all the nuclei become small before the final eighteen-nucleate stage, and hence it is difficult to pick out the original small pair. The appearances in *Agarella gracilis* indicate that the two small nuclei become the pansporoblast nuclei of Keysselitz [8], "Restkerne" of Auerbach [2]. In the later stages they usually are peripheral in position and lie between the two sporoblasts. When eighteen nuclei have been formed great changes occur in the pansporoblast. The spore walls appear for

the first time, and the nuclei all become altered in appearance. Much of the chromatin which has been so apparent in previous stages appears to concentrate in blocks on the nuclear membrane, and the nucleus in consequence becomes more ringlike in optical section while the karyosome is much diminished in size (compare Pl. VIII. Figs. 10 and 11). These alterations are correlated apparently with the specialisation in function which the nuclei now display, and render it fairly easy to distinguish between the nuclei, but at the same time make it much more difficult to determine the part played in the formation of the fully developed spore by the original pair of small nuclei. The pair of pansporoblast nuclei become slightly, and the two pairs of spore nuclei (Pl. VIII. Fig. 11, b) considerably, hypertrophied. The amoebula nuclei ("Amöboidkeimkerne") (Pl. VIII. Fig. 11, a), of which there is one pair in each spore, seem at this stage each to consist in optical section of a ring of chromatin dots with a central small karyosome. The two amoebula nuclei in each spore are closely associated, and it is not easy always to distinguish one from the other. The four polar capsule nuclei (Pl. VIII. Fig. 11, c) in each spore are alike, and are very different from the amoebulæ or spore nuclei, while near each can be seen sometimes a vacuole, the future polar capsule.

When the spore is fully developed its walls become resistant, and it is difficult to see the different nuclei (Plate VIII. Fig. 12). The polar capsules are seen to form two pairs, one long and one short pair. It should be remembered that the spore is a bivalved structure, one valve to each spore nucleus, as shown by the divergent tails of the spore (Fig. 12); and transverse sections show that each valve has one short and one long polar capsule, as indicated by the different sectional area of the capsules. The sutural ridge between the two spore valves is also well shown in such sections.

DESCRIPTION OF PLATE VIII.

All figures are reproduced at a magnification of $\times 3000$, except where otherwise stated.

- FIG. 1. Cyst in testis-follicle of *Lepidosiren paradoxa* showing clump of spores. $\times 270$.
 „ 2 and 3. Microcytes.
 „ 4. Megalocyte.
 „ 5. Fusion of micro- and megalocyte to form sporoblast.
 „ 6. and 7. Union of two sporoblasts before fusion of micro- and megalocyte is completed.
 „ 8. Fusion of two sporoblasts forming pansporoblast.
 „ 9. Pansporoblast in six-nucleate stage.
 „ 10. „ eight- „
 „ 11. Two fully formed spores in pansporoblast.
 „ 12. Mature spore. $\times 1500$.

PLATE VIII.

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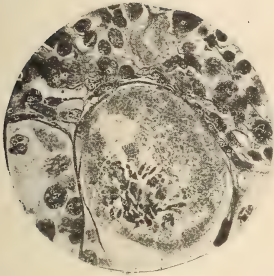


Fig. 1.

Fig. 2.



Fig. 4.



Fig. 5.



Fig. 3.

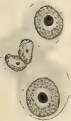


Fig. 6.



Fig. 7.

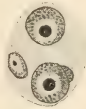


Fig. 8.



Fig. 9.



Fig. 10.

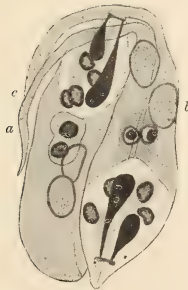


Fig. 11.

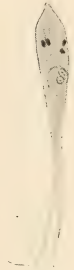


Fig. 12.

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AGARELLA GRACILIS.

P

It will be seen that the above description of the formation of the pansporoblast does not agree with that put forward for similar Myxosporidia by other writers, and a few remarks must be made to justify the interpretation put upon the figures. A lengthy discussion on the matter by me is unnecessary for two reasons, firstly, that should the figures not carry conviction then no amount of argument could do so, and secondly, that Auerbach [3] has so well discussed the various accounts of spore development in the Myxosporidia that any further general account would be superfluous. I will indicate briefly the points of difference between certain published explanations of the facts and the one which I have put forward above.

As a result of his observations, chiefly on *Myxidium bergense*, Auerbach [3] comes to the conclusion that in the Myxosporidia the pansporoblast is formed by union of a micro- with a macro- gamete. In this zygote the nuclei either unite at once to form a synkaryon or divide separately to form the numerous nuclei of the complicated pansporoblast with either one (as in *Myxidium bergense*) or two (as in *Myxobolus pfeifferi*) spores. He carefully describes and discusses the various accounts by other authors of Myxosporidian spore development, and shows how they may be brought into line with his own observations. There are at least two serious difficulties, namely the accounts by Keysselitz [8] and Schröder [11 and 12] of spore formation in *Myxobolus pfeifferi* and *Sphaeromyxa sabrazesi* respectively. In each of these two cases union of two "gametoblasts" each with one large and one small nucleus (said to be formed by division of the one original nucleus in each gametoblast) is described as taking place to form the four-nucleate pansporoblast. But Mercier [10] has shown that Keysselitz' binucleate gametoblast is formed by fusion of two distinct cells, micro- and macro- gamete, while Schröder in his original account described the binucleate gametoblast of *Sphaeromyxa sabrazesi* as being formed in the same way. Both Mercier and Auerbach, therefore, came to the conclusion that the pansporoblast is formed by the union of an original micro- and macro- gamete only. Now *Myxidium* differs from most of the Myxosporidia of which the spore development has been described in being a monosporous type, *i.e.* in forming the spores separately instead of in pairs in pansporoblasts. We are concerned here with spore development in a disporous type, *i.e.* one in which two spores are developed in one pansporoblast, and the steps of the process may be summarised thus:—

1. Differentiation of nuclei in the plasmodium into two types, small and large.

2. Formation of protoplasm around these nuclei into two types of cell, small with small nucleus, large with large nucleus. These two types of cell might be termed microcytes (Text-fig. 1, *a*) and megalocytes (Text-fig. 1, *b*).
3. Union of micro- and megalocyte to form the binucleate sporoblast (Text-fig. 1, *c*).
4. Union and fusion of two sporoblasts to form the four-nucleate pansporoblast (Text-fig. 1, *d*). 3 and 4 may occur almost simultaneously.
5. The two megalocyte nuclei divide repeatedly to form twelve nuclei (sixteen in forms with four polar capsules), while the two microcyte nuclei apparently remain as the two pansporoblast nuclei (Text-fig. 1, *f* and *g*).

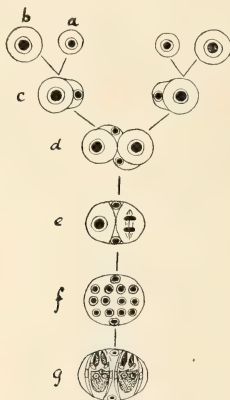


FIG. 1.

Stages 3 and 4 have each been described by different observers, but always as being the only cell fusion which occurs. Thus it will be seen that the only new conception in this description of Myxosporidian spore development is the origin of the pansporoblast from four separate cells instead of from two, as according to previous authors.

It cannot be said at present whether this form of development is universal for the disporous Myxosporidia, but the analysis of certain other accounts given above shows that there is no great difficulty in applying the same interpretations to some other forms.

As regards the monosporous type, according to Auerbach [3], the sporoblast arises as the result of fusion of a macro- and a micro- gamete. *A priori*, therefore, it would be simpler to regard the disporous type as arising from the association of two such sporoblasts, as suggested in this paper, than to believe with Auerbach that the disporous type has arisen from the monosporous "durch weitere Teilung der Pansporoblastenkerne," bearing in mind the complex character of the spores.

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(Issued separately, 15th September 1915.)

XXVIII.—The Larvæ of the Furniture Beetles—Families Anobiidæ and Lyctidæ. By James W. Munro, B.Sc.(Agr.), B.Sc.(For.), Board of Agriculture Research Scholar.

(With Plates.)

(Read 22nd March 1915. MS. received 12th February 1915.)

THE Furniture beetles are comprised in the two families Anobiidæ and Lyctidæ. The Anobiidæ include four species more or less common in houses and other buildings, namely, *Anobium domesticum*, Fourc., *Anobium paniceum*, L., *Xestobium tessellatum*, L., and *Ptilinus pectinicornis*, L. A fifth species *Ernobius mollis*, L., is rarely found indoors, but was recently sent to me in spruce flooring boards by Mr J. C. F. Fryer. I have also found it in old rafters in Aberdeenshire.

Anobium domesticum and *Ptilinus pectinicornis* are most commonly found in furniture, *A. paniceum* in stored goods, and *Xestobium tessellatum* in the heavier timbers of buildings, such as rafters, lintels, etc. *Ernobius mollis* is usually found under the bark of larch paling posts or other Coniferous timber. I have included it among the Furniture beetles on account of the two records stated above.

The family Lyctidæ comprises one genus consisting of two species, viz. *Lyctus canaliculatus*, F., and *Lyctus brunneus*, Steph. Both species bore in stored timber, furniture, and in walking-stick and umbrella handles.

These two families, Anobiidæ and Lyctidæ, both of considerable importance economically, have been known for a long time, and the adults especially have been described by various authors.

It is the object of this paper to compare and describe the larvæ of the two families in order to furnish, if possible, definite characters for their identification. Apart from the probable economic value of a knowledge of the larvæ, their study affords interest to the morphologist in the various adaptations to the peculiar mode of life of these insects.

Ratzeburg¹ and Perris,² among others, have studied and described certain of the larvæ enumerated above. Ratzeburg has figured the larva of *Xestobium tessellatum*, L., in his *Forstinsekten*, but his figure is unsatisfactory. Perris has figured the larvæ of *Ernobius mollis*, L., and also its antennæ, mandibles, maxillæ and legs; his figures are accurate.

¹ Ratzeburg's *Forstinsekten*, 1837.

² Perris, *Larves des Coléoptères*, pp. 228-250; *Annales de Soc. Entom.*, Paris, 1854, pp. 622-640.

Westwood¹ figures the larva of an *Anobium* and also its maxillæ and mandibles. Sharp² has figured the larva of *A. paniceum*.

None of these figures affords definite characters for the identification of species, however, and it is hoped that the following descriptions may serve to supply that want.

MATERIAL.

The material on which these descriptions and notes are based has been derived from various sources. In all cases the larvæ have been obtained working alongside the adult insect, and no larvæ have been used whose identity has not been so confirmed.

The material for the work on *A. domesticum* has been obtained from three sources, beech panelling from a dwelling-house in London, a willow basket-work mat, and rough boarding from an outhouse in Aberdeen. The *Ernobius mollis* material has been got from larch paling posts in Aberdeenshire. *Anobium paniceum* was received in quantity in dog biscuits through the courtesy of Mr C. J. Gahan, M.A. For *Lyctus canaliculatus* I am indebted to Mr J. C. F. Fryer, M.A.; and for *L. brunneus* to Mr R. Burdon, M.A., of Cambridge. Dr Stewart MacDougall supplied the *Ptilinus* material, obtained from a chair in a church in Arran. The description, figures and notes on *Xestobium tessellatum* are the result of work done by me as Sir John Wolfe Barry student at the Imperial College of Science and Technology, London, and are published here by the courtesy of Professor Maxwell Lefroy.

METHODS.

As far as possible the larvæ for examination have been kept in their natural habitat until required. They were then boiled for a minute and preserved in 3 per cent. formalin. For the general examination living larvæ were used, in order that their natural aspect might be obtained. Boiling invariably causes the larvæ to distend, causing the head to appear unduly small. The head, on account of its structure and thicker chitin, does not extend. Further, the natural attitude of the Anobiid and Lyctid larvæ is curved; boiling tends to straighten them.

For detailed examination the larvæ were boiled for about five minutes in dilute (10 per cent.) caustic potash, and then allowed to cool in the solution for ten minutes. After being washed in water they were ready for dissection. Careful boiling in the caustic is essential, otherwise the larvæ may burst. On boiling in caustic potash the contents of the

¹ Westwood, *Classification of Insects*, vol. i., p. 269, *et. seq.*

² Sharp, *Camb. Nat. Hist.*, vol. vi., "Insects," p. 247.

alimentary canal appear as a brown mass extending from the head to the anus. When this streak attains a dark brown colour no further boiling is required, as a rule. In some cases, however, it may be necessary to sever the head from the body and boil it separately to soften and remove the mass of muscle it encloses. In such cases great care is necessary in dissection to prevent the head being torn and its appendages folded or distorted beyond recognition.

INSTRUMENTS.

For dissection a pair of very fine scalpels, or a pair of dissecting needles sharpened like a blade at the points, and a pair of fine-pointed forceps are all that is necessary. I have found it best to examine the larvæ first with a simple dissecting microscope having magnifications of 8, 12 and 20 diameters. This last power is sufficient to distinguish the various parts of the head and the segments of the body, and in some cases the spiracles and spinules. For closer and detailed examination, and for sketching complete organs like the head or thorax, a Porro-Prism is very useful. Best of all, however, is a binocular dissecting microscope. The one I have used has a 10-diameter eyepiece, and objectives with working distances of 44 mm. and 32 mm. respectively. These have proved adequate for the most detailed examinations. In making sketches of the mouth-parts, slides were mounted and sketches made through an ordinary compound microscope and a camera lucida of the Abbé type.

GENERAL DESCRIPTION OF THE LARVÆ.

The larvæ of the Anobiid and Lyctid beetles are admirably adapted to the life they lead as wood-borers. They are soft fleshy grubs with a hard chitinous head sunk in the first segment of the body. The mandibles (or jaws) are well developed and powerful. The body is curved enabling the larva to progress in its tunnel by alternately extending and distending, thus pressing on the sides of the tunnel. This method of locomotion is further assisted in the Anobiid type of larva by the presence of spinules on the dorsal surface, and in the case of *Ptilinus* on the sides, of the body segments. The legs are six in number and very feeble. The antennæ are much reduced and sunk in pits, except in the Lyctid larvæ. I have been unable to make out the presence of eyes of any kind.

There are then two types of these larvæ, Anobiid and Lyctid. They are very much alike in appearance, and, to the casual observer, they appear quite similar. A general description of the two types may be useful before

proceeding to detailed descriptions and classification. For the Anobiid type *Anobium domesticum*, Fourc., may be taken, and for the Lyctid type *Lyctus brunneus*, Steph.

GENERAL DESCRIPTION OF THE LARVA OF ANOBIUM DOMESTICUM (FOURC.).

In general appearance this larva is a curved, white, fleshy grub with wrinkled body, well-marked yellowish head, and three pairs of thoracic legs. The whole of the body is clothed with fine hairs (Fig. 1). The larva

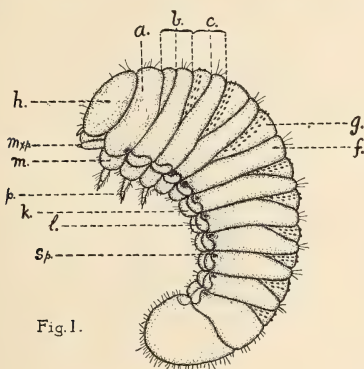


Fig. 1.

Larva of *Anobium domesticum*, side view.

<i>h.</i>	Head.	<i>sp.</i>	Spiracle.
<i>a.</i>	Pro-thorax.	<i>p.</i>	Foot.
<i>b.</i>	Meso-thorax.	<i>k.</i>	Hypo-pleural fold.
<i>c.</i>	Meta-thorax.	<i>l.</i>	Epi-pleural fold.
<i>mxp.</i>	Maxillary palps.	<i>g.</i>	Prescutal fold.
<i>m.</i>	Pedal fold.	<i>f.</i>	Scutellar fold.

is made up of fourteen segments including the *head* which forms the first segment, the next three segments form the *thorax*, and the remaining ten the *abdomen*.

The 8th and 9th abdominal segments are larger than the others. The 10th consists of three lobes surrounding the anus. Each of the first eight abdominal segments bears a pair of spiracles, as also does the first thoracic. The pro-thoracic spiracles are slightly larger than those on the

abdominal segments. The thoracic segments each bear a pair of five-jointed legs or feet.

The Head.

The *head* of the larva viewed from above with a high-power lens, or better with a dissecting microscope, shows the following parts (Fig. 2):—

The *Frons* (*f*)—A large triangular region occupying the middle of the area in view.

The *Epicranium* (*e.p.*)—A divided region adjoining the frons, from

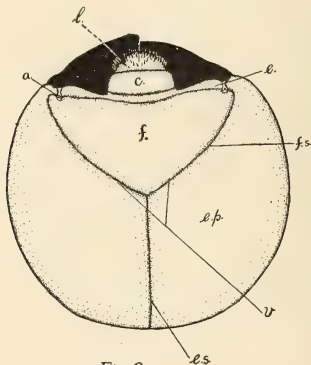


Fig. 2.

Head of larva of *A. domesticum* seen from above.

which it is separated by the *frontal sutures* which unite posteriorly to meet the *epicranial suture* (*e.s.*) which runs backward.

The *Antennae* (*a*) lie in two little pits, one at each extremity of the anterior border of the frons.

The *Epistome* (*e*)—A narrow, thicker band of chitin, extends from pit to pit along the anterior border of the frons.

The *Clypeus* (*c*)—A broader transverse plate, adjoins the epistome along the middle third of its anterior border.

The *Labrum* (*l*)—A somewhat narrower plate covered with tiny bristles, adjoins the anterior border of the clypeus.

The *Mandibles* are seen below the clypeus and labrum extending from side to side of the head and meeting in the median line. They are dark brown in nature and have been coloured black in the figure.

Viewed from the underside the head shows the following regions (Fig. 3):—

The *Occipital foramen* (*o*)—A large, somewhat oval-shaped opening.

The *Genæ*, or cheeks, surround the occipital foramen on either side.

The *Gular plate* (*i*) lies above the anterior border of the occipital foramen.

The *Maxillæ* and *Labium* with their palps lie anterior to the gular plate; they have been removed in Fig. 3, but are shown in more detail in Fig. 5.

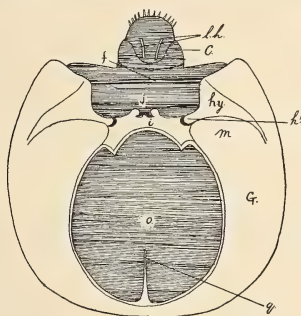


Fig. 3.

Head of larva of *A. domesticum* seen from below; the maxillæ, labium and mandibles removed.

The *Mandibles* again appear as two triangular structures extending from side to side of the head.

If the maxillæ, labium and mandibles are removed, as in Fig. 3, the following additional regions can be seen:—

The *Maxillary foramen* (*j*)—A rectangular cavity lying above the gular plate. On its lateral borders lie two less definite plates—the *hypostomes* (*hy*) bearing the *maxillary condyles* (*h*). On its anterior border is a narrow strip of chitin called by Hopkins¹ the *hypopharyngeal bracon* (*f*).

The *epistome*, *clypeus* and *labrum* can also be seen.

Attached to the *labrum* are two little rods, the *labral hooks* (*l.h.*).

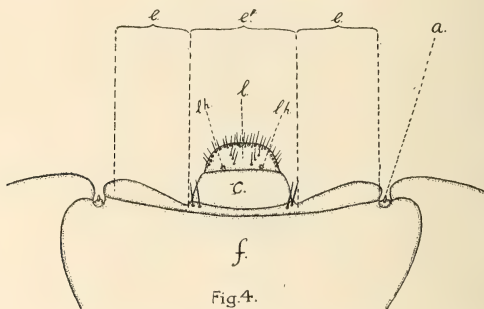
In the figure these rods appear white, the *frons*, *epistome*, *clypeus* and

¹ Hopkins, *The genus "Dendroctonus,"* U.S. Bureau of Entomology, Bulletin 1909. To save duplication the nomenclature of Hopkins has been followed with slight modifications. In this an excellent description of the larvæ of the genus *Dendroctonus* (Scolytidæ) is given.

labrum are shaded, as are also the cavities of the *maxillary foramen* and the *occipital foramen*.

The following parts of the head, already mentioned, will be frequently referred to in the classification and detailed descriptions, and they merit further consideration:—the *frons*, the *epistome*, the *clypeus*, the *labrum*, the *antennæ*, the *mandibles*, the *maxillæ*, and the *labium*.

The *Frons*.—This region varies little in the various species except in its relation to the epistome, which affects its anterior border. In *A. domesticum* the anterior border is transverse. In *A. paniceum* it is slightly curved. In *Ptilinus pectinicornis* it is markedly curved. In



Frons and epistome of *A. domesticum*.

E. mollis it is indented, and the antennal pits are shallow, as is also the case in *X. tessellatum*.

The *Antennæ* are much reduced. I have been able to distinguish only two joints. The antennæ vary in size according to the species. Perris (*loc. cit.*) is of the opinion that they are four-jointed, but states that he has discerned only two joints, which he figures.

The *Epistome*.—This is a most important region for taxonomic characters. For convenience it may be divided into three regions, a median or clypeal region adjoining the clypeus, and a region on each side extending between the antennal pits and the clypeal region (Fig. 4). This clypeal region bears a varying number of bristles. The lateral regions, except in *X. tessellatum*, are free of bristles.

The *Clypeus*.—This appears to be a continuation of the epistome. It is a thinner plate destitute of bristles.

The *Labrum*.—This is slightly stouter than the clypeus. Near its posterior border two papillæ occur, one on each side of the median line. These are the points of attachment of the labral hooks, which serve for the attachment of the muscles controlling the movement of the labrum. One observes their function when in dissection the removal of the muscles causes the labrum to move with them. The anterior and lateral borders of the labrum are fringed with stout, short bristles. Similar bristles also occur on either side of the median line diverging anteriorly in a V-shaped arrangement.

The *Mandibles* in *A. domesticum* are stout and triangular. Their inner or

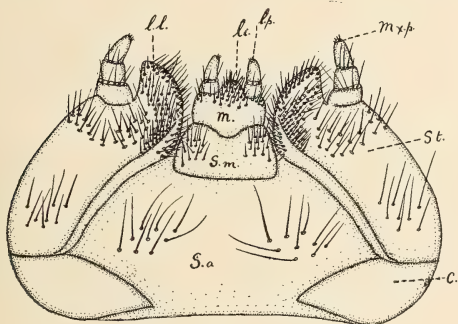


Fig. 5.

Maxillæ and labium of *A. domesticum*.

biting margin bears three teeth of which the first or apical is the largest. The mandibles move laterally. They are controlled by two sets of powerful muscles—the abductor pulling them apart, the adductor closing them. The mandibles articulate by two condyles—a ventral articulating in a pit in the hypostome, and a dorsal articulating in the epistome. They vary in size according to the species—those of *Ernobius mollis* and *Xestobium tessellatum* being larger.

The *Maxillæ*.—The first pair of maxillæ consists each of a *cardo*, *stipes* and *lacinal lobe*. There is no distinct galea discernible (Fig. 5). The *cardo* (*c*) is a small more or less triangular piece free of bristles. The *stipes* (*s*) is a long narrow piece bearing a three-jointed telescopic palp. The *lacinal lobe* (*l*) is somewhat rounded and densely clothed with bristles. In *Ptilinus*

pectinicornis (Fig. 6) the lacinial lobes are more rounded than in *A. domesticum* and the others.

A fold running parallel to the stipes has been the subject of discussion by Perris.

The apical joint of the maxillary palp bears a number of small papillæ.

The *Labium* consists of the fused second maxillæ. It comprises:—

The *mentum* (*m*)—bearing the palps and ligula.

The *submentum* (*s-m*)—an inferior or posterior piece.

Below or behind the submentum and partly surrounding it is the

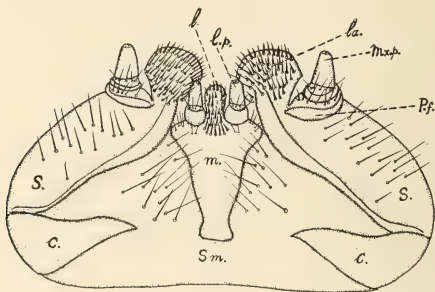


Fig. 6.

Maxillæ and labium of *Ptilinus pectinicornis*.

submental area. The labial palps are two-jointed, and as in the maxillary palpi their apical joints bear papillæ.

The mentum bears a number of bristles along its upper margin. The submentum bears a group of bristles on each side.

In *Ptilinus pectinicornis* (Fig. 6) the mentum is elongated and narrow. The submentum is not distinct from the submental area. The ligula is long and densely bristled.

The Thorax.

The *thorax* of the larva of *A. domesticum* (Fig. 1) is made up of three segments—the first adjoining the head called the *pro-thorax*, a second the

meso-thorax, and a third the *meta-thorax*. All three are distinct, and each bears a pair of legs.

The *Pro-thorax*.—This is the largest of the three thoracic segments. It partly encloses the head, and viewed laterally with a high-power lens shows the following folds:—

The *scutellar* fold, taking up almost the whole of the dorsal and lateral regions.

The *pedal* fold, which lies just below it and partly conceals the foot.

The scutellar fold of the pro-thorax bears no spines but is sparsely covered with hairs. It bears a pair of spiracles, one on each side, on its posterior margin just above the pedal fold.

The *Meso-thorax*.—This differs from the pro-thorax in that it is smaller and shows four folds.

The *scutellar* fold is present as before.

The *epi-pleural* fold is a small fold lying below the scutellar fold.

A *pedal* fold is present as before.

The *prescutal* fold is the fourth fold, small and narrow, lying dorsally and adjoining the scutellar fold anteriorly.

No spiracles are present on the meso-thorax.

The *Meta-thorax* resembles the meso-thorax except that the prescutal fold bears two rows of stout spinules, which curve backwards and resemble a bent collar-stud. These spinules are undoubtedly of use in locomotion, and, according to Perris, are peculiar to the Anobiid larva. The meta-thorax bears no spiracles.

The Abdomen.

The first eight abdominal segments are similar. Viewed laterally under a high-power lens they show four folds, a *prescutal*, a *scutellar*, an *epi-pleural*, and a *hypo-pleural* fold which lies below the epi-pleural fold, and takes the place of the pedal fold of the thoracic segments.

The prescutal folds of the first eight segments of the abdomen bear two rows of spinules, and the scutellar folds a pair of *spiracles*. The spiracles are indistinct and appear to be unprotected by any external structure. The arrangement of the spinules on the folds of the abdominal segments varies with the species. The 9th abdominal segment is the largest of all; it has no prescutal fold and carries no spiracle. The 10th abdominal segment is not visible laterally. It is represented by three folds surrounding the anus as before stated.

THE LARVA OF LYCTUS BRUNNEUS (STEPH.).

I describe the larva of this species as representing the Lyctid type (Fig. 7).

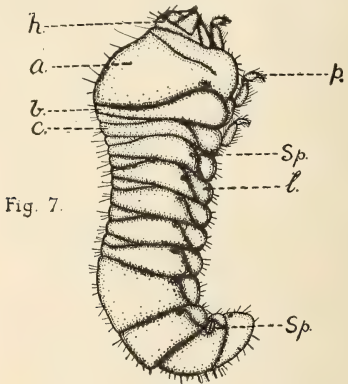


Fig. 7.

Larva of *Lyctus brunneus*, side view.

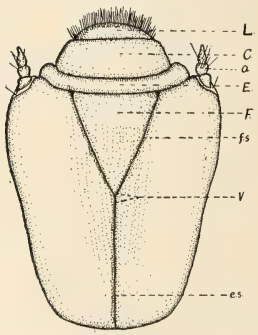


Fig. 8.

Head of larva of *L. brunneus* seen from above.

The Head.

The *head* (Fig. 8) is long and quadrangular in shape, and is almost

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completely sunk in the pro-thorax. The *frons* is small in proportion to the size of the head. The *epistome* is large. The *antennæ* are long and four-jointed.

The *Epistome* (Fig. 9).—The epistome in *Lyctus* is not so well defined as in *Anobium*, and I have thought it best to consider the epistome as consisting of two parts—a stouter definite region adjoining the frons, and a thinner less definite and flexible region partly surrounding the clypeus.

The *Clypeus*.—This structure is quite different from that of the Anobiid type. It bears numerous bristles and is narrower posteriorly, contrasting with the Anobiid which is broadest posteriorly.

The *Labrum* in *Lyctus* is fringed with very fine bristles totally different from those of *Anobium*. They form a fringe round the anterior border, and are finer and longer than the Anobiid labral bristles. The labral hooks call for no special comment.

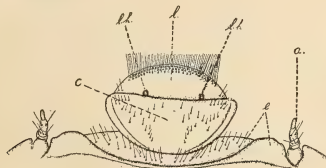


Fig. 9.

Frons and epistome of *L. brunneus*.

The *Mandibles* are smaller than in the Anobiid type, but are otherwise similar.

The *Maxillæ* and *Labium* differ from those of *A. domesticum*, but not greatly.

The *Lacinial lobes* in *Lyctus* are broader than those in *Anobium*, and in *Lyctus* bristles are absent on the submentum. In the Anobiid type the submentum bears bristles. The maxillary palps in *Lyctus* are three-jointed, the labial palps one-jointed.

The Thorax (Fig. 7).

The *Pro-thorax* in *Lyctus* is remarkably broad. I have been unable to make out other than a scutellar fold. It bears a pair of spiracles.

The *Meso-thorax* is much narrower. It has no prescutal fold and the pedal fold is small.

The *Meta-thorax* has no pedal fold. The *legs*, or feet, are three-jointed and hairy.

The Abdomen.

The first five abdominal segments are similar and show *prescutal*, *scutellar* and *hypo-pleural* folds.

The *epi-pleural* folds when the larva is viewed laterally are hidden by the *hypo-pleural* folds. The sixth, seventh and eighth segments have no prescutal folds. The ninth has no hypo-pleural fold, and the tenth segment consists of three lobes round the anus.

Spiracles.—The first eight abdominal segments each bear a pair of spiracles. The pair on the eighth segment are four times as large as the others, a peculiarity which, according to Perris, serves to distinguish the larvæ of *Lyctus* from all others.

CLASSIFICATION OF THE LARVÆ.

The larvæ under consideration may be classified as follows:—

A.—Feet five-jointed. Head more or less round, not deeply sunk in the thorax. Antennæ showing only two joints. Pro-thoracic spiracles slightly larger than the others. Scutellar fold of pro-thorax not markedly broad. Spinules on the back and sometimes on the sides of the various segments.

1. The meso-thorax has a prescutal fold.

- (a) Spinules on the prescutal folds of the meta-thorax and first 8 abdominal segments. No spinules on the 9th abdominal segment *A. domesticum*.
- (b) No spinules on the prescutal fold of the meta-thorax, but on all the prescutal folds of the first 8 abdominal segments, and on the sides of the 9th segment near the anus. Head markedly hairy. Spinules small *A. paniceum*.
- (c) Spinules on the prescutal folds of the meta-thorax and first 8 abdominal segments, on the scutellar folds of the 8th and on the sides and below the 9th. Spinules large *E. mollis*.
- (d) Spinules on the prescutal folds of the meta-thorax and of the first 6 abdominal segments, and on the sides of the 9th *X. tessellatum*.

2. The meso-thorax has no prescutal fold. Spinules small.

- (a) Spinules on the prescutal folds of the meta-thorax and of the first 8 abdominal segments, on the scutellar folds of the meso-thorax and of abdominal segments 2, 3 and 4, and on the hypo-pleural folds of abdominal segments 2 to 8, and on the sides and below the 9th *Ptilinus pectinicornis*.

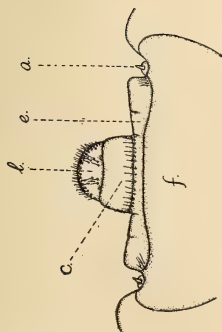


Fig 10.

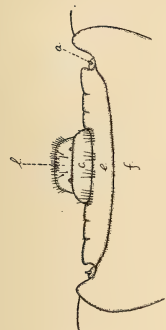


Fig. 11.

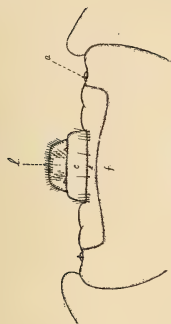


Fig. 12.

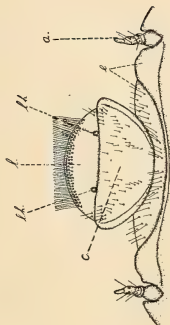


Fig. 14.

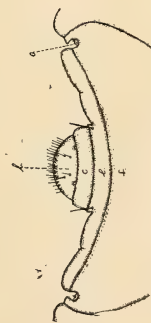


Fig. 13.

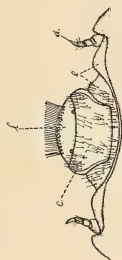


Fig. 15.

B.—Feet three-jointed. Head rectangular, deeply sunk in the pro-thorax. Antennæ showing four joints. Eighth pair of abdominal spiracles very large. Scutellar fold of pro-thorax very broad. Spinules absent.

1. Clypeus twice as broad as long; the posterior border a simple curve *Lyctus brunneus*.
2. Clypeus not twice as broad as long; narrow posteriorly and widening anteriorly *L. canaliculatus*.

Perris (*loc. cit.*) has classified the larvæ of the Anobiidæ in a similar manner, basing his distinctions on the spinules. In so far as the above table does not agree with his, I append a comparative summary.

PERRIS.	MUNRO.
<i>A. domesticum</i> .—2 or 3 rows of spinules on the first 2 abdominal segments; 1 row on abdominal segments 3 to 6. A few spinules on 7 and 8 and on the sides of the 9th.	2 rows on the first 8 abdominal segments. None on the 9th.
<i>A. paniceum</i> .—Numerous spinules on the first 5 abdominal segments only, with a few on the 9th.	Two rows only on all the abdominal segments.
<i>E. mollis</i> .—Spinules small.	Spinules large.
<i>P. pectinicornis</i> .—Small asperities on the first 4 segments of the abdomen below the median line on each side.	Tiny spinules (small asperities) on the scutellar lobes of abdominal segments 2, 3 and 4, and on the hypo-pleural lobes of segments 2 to 8.
<i>X. tessellatum</i> .—I agree with the description given by Perris of <i>X. tessellatum</i> .	

The two accounts differ only in small respects. The arrangement of the spinules given by me was uniform and constant in all the larvæ I examined of any one species. Finally three larvæ of each species were taken at random, and in each lot the arrangement of the spinules was uniform and constant. It may be that with a change of skin certain spinulæ appear or disappear, and until any one of these larvæ is examined in all its stages, or a series of larvæ in the different stages, nothing further can be said. One point, however, worthy of mention is that in larvæ I examined of different size, and presumably therefore of different age, there was no difference in the arrangement of the spinules.

Further characters of the larvæ were looked for to provide means of identification. These are presented by the forepart of the head, especially the epistome, the clypeus and the labrum.

The following classification is based on these characters:—

A.—Feet five-jointed. Epistome rigid and stouter than the clypeus.

1. Clypeal region of the anterior border of the epistome depressed.

(a) Lateral regions divided in two by a slight depression. Median (clypeal) region bearing four bristles at its extremities and a pair lying between these. Labrum with numerous spines on each side of the median line *E. mollis*.

(b) Lateral regions divided in three by two depressions. Clypeal region bearing five lateral bristles and two sets of three median bristles. Labrum with only two or three spines on each side of the median line *A. paniceum*.

2. Clypeal region of anterior border of epistome raised.

(a) Lateral regions divided in two by a slight depression.

(i.) One lateral bristle at each extremity of the median region *P. pectinicornis*.

(ii.) Numerous bristles extending along the whole of the median region *X. tessellatum*.

(b) Lateral regions not divided. Two pairs of lateral bristles

A. domesticum.

B.—Feet three-jointed. Epistome flexible; less stout than the clypeus.

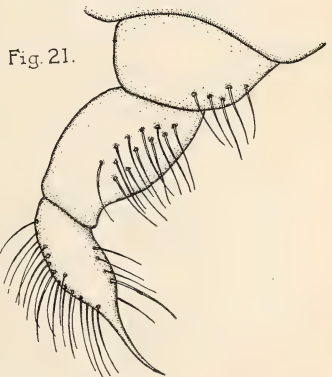
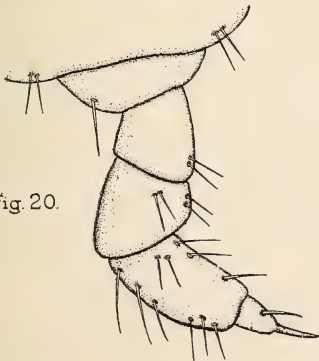
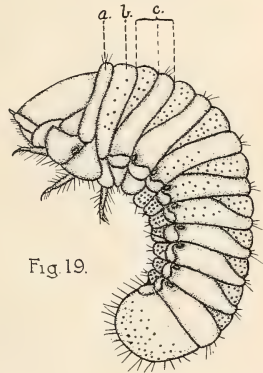
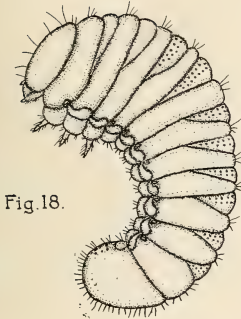
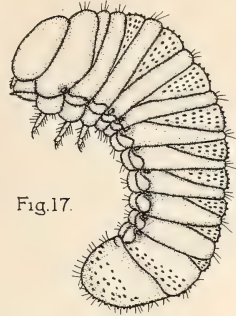
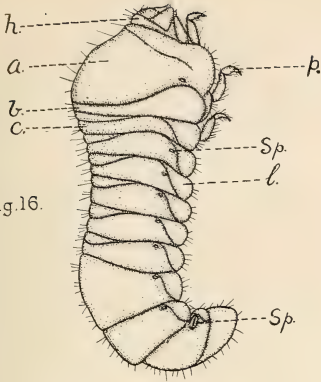
1. Clypeus twice as broad as long; the posterior border a simple curve *Lyctus brunneus*.

2. Clypeus not twice as broad as long; narrow posteriorly and widening anteriorly *L. canaliculatus*.

GENERAL NOTES ON THE LARVÆ.

Anobium domesticum (Fig. 1). This larva has already been described. The following points may be given in regard to it:—Length 6·7 mm. The spiracles are extremely difficult to detect, more especially the abdominal ones. Adult and larva attack both coniferous and hardwooded timber. Beech wood appears specially prone to attack. *A. domesticum* is the beetle most commonly found in furniture.

Anobium paniceum (Fig. 18). Length 5·6 mm. Similar to *A. domesticum* but with smaller spinules. In this larva the spiracles can be more readily made out although careful scrutiny is still necessary. Sharp (*loc. cit.*) states



that he was unable to detect the abdominal spiracles. *A. paniceum* is commonly found in stored goods, hay, biscuits, leather, etc.

Ernobius mollis (Fig. 17). Length 7·8 mm. In *E. mollis* the head is somewhat darker than the preceding species. The spinules are stouter and more marked, and the spiracles being reddish-brown are more readily discerned. It is doubtful if *E. mollis* is at all common as a wood-borer. Its usual habitat is under the bark of coniferous paling posts and, according to Perris, in the pith canal of Scots pine twigs.

Xestobium tessellatum. Length 9-12 mm. This is the largest of the Anobiid larvæ. It can readily be distinguished from the others by its damage, the flight holes being larger than the others. *X. tessellatum* attacks chiefly willow, oak and chestnut (*Castanea vesca*). It has caused enormous damage in the roof of Westminster Hall and the roof of Eltham Palace. In Westminster Hall one of the wall-posts, a huge beam 2 feet square and over 20 feet long has been reduced to a mere shell for a distance of 15 feet.

Ptilinus pectinicornis (Fig. 19). 7-8 mm long. This larva can be distinguished from the others by the absence of the prescutal fold from the meta-thorax. The spinules, too, are more rounded in the preceding species, and occur as indicated in the table on the scutellar folds of the second, third and fourth abdominal segments, and on the hypo-pleural folds of all the abdominal segments except the first and last. The larva of *Ptilinus* seems to grind the wood into a finer dust than the other Anobiid larvæ.

Lyctus brunneus (Fig. 16) and *Lyctus canaliculatus*. Length 5-7 mm. The larvæ of these two species differ only in the conformation of the epistome and clypeus. They differ, as stated, from the Anobiid larvæ in having the eighth abdominal spiracle remarkably enlarged. The head, too, being more deeply sunk in the pro-thorax appears smaller, only part of the frons, the clypeus, the labrum and mandibles being visible from above. The thoracic segments also are broader than the abdominal segments, a feature which is less noticeable in the Anobiid larvæ.

The larvæ of *Lyctus* appear to occur in much larger numbers than the Anobiid larvæ, if I may judge from the material in my possession which is reduced to an extremely fine powder by their boring.

In conclusion, I wish to acknowledge my indebtedness to Dr Stewart MacDougall for his help and advice in all my work, and for the facilities he has given me for carrying it out.

EXPLANATION OF PLATES.

Plate IX. Figs. 10-15.

- Fig. 10. Epistome of *X. tessellatum*.
 „ 11. Epistome of *A. paniceum*.
 „ 12. Epistome of *E. mollis*.
 „ 13. Epistome of *P. pectinicornis*.
 „ 14. Epistome of *Lyctus brunneus*.
 „ 15. Epistome of *L. canaliculatus*.

Lettering on Plate IX.

a = antenna ; *c* = clypeus ; *l* = labrum ; *l.h* = labral hooks ; *f* = frons ; *ee'e* = epistome ;
ee = lateral areas ; *e'* clypeal area.

Plate X. Figs. 16-21.

- Fig. 16. Larva of *Lyctus brunneus*.
 „ 17. Larva of *E. mollis*.
 „ 18. Larva of *A. paniceum*.
 „ 19. Larva of *P. pectinicornis*.
 „ 20. Leg of *A. domesticum*.
 „ 21. Leg of *Lyctus brunneus*.

Lettering on Plate X.

h = head ; *a* = pro-thorax ; *b* = meso-thorax ; *c* = meta-thorax ; *p* = foot ; *l* = epi-pleural
 fold ; *sp* = spiracle.

(Issued separately, 15th December 1915.)

XXIX.—Some Points in the Natural History of the Carboniferous Period in East Scotland. Address delivered on 23rd November 1914 by the retiring Vice-President, **B. N. Peach**, LL.D., F.R.S.

INTRODUCTION.

IN my Presidential address to this Society in November 1885, I cited several examples of the association of certain forms of animal and plant remains with particular kinds of sediment. In that address, given thirty years ago, I considered that the repeated disappearances of truly marine forms from strata between the limestones of the Scottish Carboniferous Series, and their reappearance with each successive limestone band gave evidence in support of Barrande's *Doctrine of Colonies*. Later investigation, however, soon convinced me that the constant disappearance and reappearance were due only to migration of forms following a suitable habitat, and that the interval of time represented by our Scottish Carboniferous Limestone Series was insufficient to allow of any very appreciable genetic change in the truly marine forms. Hence, also, arose our difficulty in zoning this section of our Carboniferous rocks. Further study of the fossil contents of our Palæozoic rocks has led me to abandon Barrande's fascinating doctrine entirely. In my present address, I purpose to amplify that part of my subject which was illustrated by examples taken from the Scottish Carboniferous rocks in the light of the experience gained during the recent revision of the Scottish Coal-fields by the Geological Survey.

UPPER OLD RED SANDSTONE.

For the elucidation of my subject of address it is necessary to describe the nature of the floor upon which the Carboniferous rocks were laid down, and the order of succession of those deposits in East Scotland (see Fig. 1, p. 239).

The Old Red Sandstone period must have been one of considerable crustal movement in what is now Scotland, for the Upper Old Red Sandstone, which really forms the natural base of the Carboniferous series of rocks, is everywhere unconformable to the rocks of all other formations older than itself, including those of Lower Old Red Sandstone age in the south, and the Middle Old Red Sandstone in the Orkneys.

The study of the Upper Old Red Sandstone shows that it was an Epicontinental Formation, laid down upon a land surface, which, in the south of Scotland, was one of high relief, for we have still preserved to us, in

the Southern Uplands and the Cheviots, the old valleys filled up with coarse conglomerates which are of the nature of torrential deposits. Owing, doubtless, to a general subsidence of the area, these deposits and the enclosing hills are overlaid by Red Sandstones and marls alternating with conglomerates, indicating that they were laid down either in enclosed water basins subject to periodic desiccation, or upon land surfaces where torrents debouched upon the plains leaving their deposits to be partly assorted by wind during dry intervals. At several horizons, but more particularly near the top of the pile of sediments, the marly beds contain nodules and sometimes considerable beds of cornstone, a concretionary limestone evidently formed, like Kunka of India, within the sediments after deposition and at the upper limit of saturation, the lime being largely derived from contemporary volcanic rocks.

Accompanying this subsidence of the area, and probably in some way directly connected with it, vulcanicity manifested itself; and volcanoes broke out in at least three separate areas. The most extensive volcanic platform they gave rise to, is that which extends from the Berwickshire Merse to beyond Birrenswark in Dumfriesshire. A second is situated in the Kilsyth part of the Campsie Plateau, while the third occurs sporadically scattered through the Orkney and Shetland Islands.

The mode of occurrence of the fossil fishes, which are generally found crowded together and almost whole, sometimes enclosed within an inch or so of strata, while the intervening large masses of sediment only yield an occasional detached scale or tooth, had long suggested to geologists that the fishes had been entombed in shoals in dried-up pools. This conjecture has recently been confirmed during the excavations at Dura Den, carried out by the British Association Committee appointed at the Dundee meeting in 1912. The bed containing the crowded fish remains, belonging to several genera, was found to be sun-cracked. Further, the presence of *Phaneropleuron*, one of the Dipnoi or lung-fishes, and the nearly allied genus *Holoptychius*, in the assemblage of fishes got there, is strong evidence in favour of land-locked and not marine conditions of deposit.

Evidence of desiccation during the deposit of the Upper Old Red Sandstone near Edinburgh is admirably shown in the Suburban railway cutting at Craiglockhart, where the marls and more clayey bands are widely and deeply fissured by sun-cracks that are filled in by sandstone continuous with the overlying sandstone layers.

ONCOMING OF THE CARBONIFEROUS PERIOD IN SCOTLAND.

The continued depression which converted the Upper Old Red land surface into the Carboniferous sea was widespread and more pronounced in

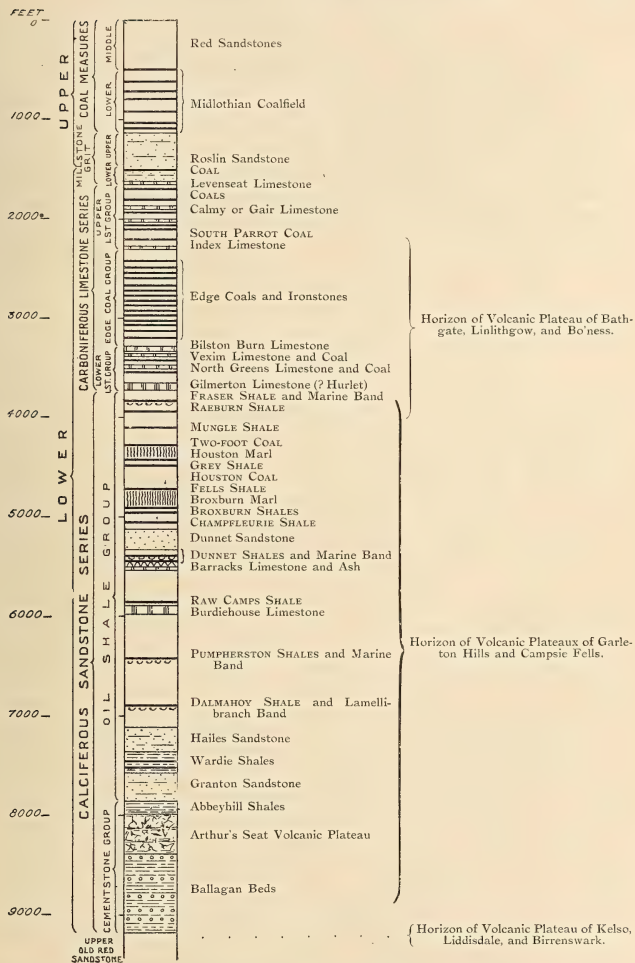


FIG. 1. GENERAL VERTICAL SECTION OF CARBONIFEROUS STRATA IN THE LOTHIANS
(after H.M. Geological Survey).

Belgium and mid England than farther north. In Scotland the portions of the country that had been more or less levelled up by the Upper Old Red Sandstone sediments formed a gently sloping plain that became subject to incursions of the sea, and only the older Palæozoic rocks of parts of the Southern Uplands, Pentlands, and of the Cheviots, that had not been covered up by them, stood out as islands and were not entirely enveloped till Upper Carboniferous time. Thus it happened that the lowest members of the Carboniferous strata were deposited conformably upon the sediments of the Upper Old Red Sandstone. At the same time there seems to have been a compensating elevation of a continental region towards the north-west, of which our area became the coastal belt.

CALCIFEROUS SANDSTONE SERIES.

The lowest great division of the Carboniferous strata in Scotland is known as the Calciferous Sandstone Series from the constant recurrence throughout it of limestones. The term originally included the Upper Old Red Sandstone of midland Scotland and part of the Scottish Carboniferous Limestone Series, but is now restricted to the lowest division of the Carboniferous system, which comprises (*a*) a lower or Cementstone Group, and (*b*) an upper or Oil-shale Group (Fig. 1). These two contrasted types of sedimentation are typically developed only in midland Scotland, but not over the whole of that area.

(*a*) CEMENTSTONE GROUP.

The rocks entering into this group vary considerably according to the area in which they have been deposited. In central Scotland what is known as the Ballagan type is most prevalent, and best shown in the Campsie district. Where typically developed, the rocks show a rythmical alternation of mudstones and muddy cementstone bands with occasional beds of calcareous sandstone. The cementstone bands are mostly a chemical deposit, though many of them contain remains of Ostracods and bivalve Phyllopods. Large concentric pisolites also occur occasionally, suggesting secretion through lowly plant agency. More or less gypsum is associated with the cementstones, sometimes in layers, but more often in veins; while pseudomorphs after rock salt have been found in such strata, in Salisbury Crags, by Mr A. Macconochie. Specimens showing pseudomorphs after rock salt are exhibited in the Perthshire Naturalists' Museum at Perth, obtained from the small outlier of Ballagan beds exposed in the railway cutting at Dron, a little to the south of Bridge of Earn. This outlier is the only remnant of the Carboniferous system that is known to occur to the north of the Ochil Hills

in East Scotland. Sun-cracks are almost everywhere observable in these beds.

These deposits were evidently laid down in lagoons cut off from the sea and subject to periodical desiccation. Their fossil contents seem to bear out this point. In the Edinburgh district, *Estheria* occurs in a cementstone band in the Camstone Quarry above the Hunter's Bog. Remains of fishes—*Rhizodus*, *Elonichthys striatus* and *Callopristodus pectinatus*—have been recorded by Dr Traquair from the ash bed from under St Anthony's Chapel,¹ while Mr Kirkby records a list comprising ostracods, fish and plants from the site of the *Scotsman* office in Edinburgh, and shows that the ostracods were marine in facies.²

To the east of the area just mentioned, especially in East Lothian, a different type of sedimentation has taken place, showing a great prevalence of sandstone and sandy calcareous beds. This probably indicates the position of the sand bars that successively shut off the lagoons from the outer estuary or open sea.

In East Fife, Messrs Craig and Balsillie, who are at present at work on the sections exposed to the north of Fife Ness, inform me that, on the top of anticlines bringing up the cornstone and cherty bands that represent the local top of the Upper Old Red Sandstone, they find about 10 feet or so of sediments of true Ballagan type. Above this horizon there is the rythmic succession of sandstones, shales and lamellibranch and *Spirorbis* limestones so well described by the late J. W. Kirkby in his paper on the Randerstone section,³ which is reproduced by Sir Archibald Geikie in the Geological Survey Memoir on East Fife (pp. 123-126). The sequence of strata overlying the Randerstone beds exposed on the shore between the base of the Billow Ness Sandstone and Anstruther was described by Mr Kirkby, and this description is reproduced by Sir A. Geikie in the same Memoir (pp. 96-99). The exact point where the two sections overlap cannot be definitely determined; but it shows throughout, the same rythmical type of sedimentation, pointing to an estuarine condition of deposit rather than that of open water. But freshwater conditions, and even land surfaces, occurred within the area during this period, for No. X Limestone, shown in Kirkby's Randerstone section near its base, is a matted mass of the shells of *Carbonicola elegans* belonging to the Unionidæ—a freshwater group; while, near the top of his section, two coal seams are represented.

This area then seems to have lain, for most part of the time, outside the

¹ "The Geology of the Neighbourhood of Edinburgh," *Mem. Geol. Sur.*, 1910, p. 100.

² "Summary of Progress," *Mem. Geol. Sur.* for 1898, p. 131.

³ *Trans. Edin. Geol. Soc.*, vol. viii., pp. 61-75, 1905.

barriers that held in the Ballagan lagoons. South of the Firth of Forth, a similar series of deposits is exposed towards the base of the group on the shore near Cockburnspath.

Still farther to the south, the Mërse of Berwickshire is floored by a group of rocks of Ballagan type.¹ Towards the base they are much more estuarine in character, for they hold a crustacean and fish fauna not unlike that of the Langholm Scorpion bed, though many of the species are different. In both areas the specimens are preserved whole and in large numbers, as if they had been poisoned by volcanic exhalations. That they were laid down in close proximity to land is shown by their having yielded at least two genera of myriopods, in addition to scorpions as well as the perfectly preserved plant stems described by Dr Kidston. The lagoons here appear to have been banked up on the south partly by the Old Cheviot land surface. To the east they may have been blocked up by sandbanks, for the Fell Sandstones cross over into Scotland near Berwick-on-Tweed.

Farther to the south-west, in Liddisdale, a modification of the Ballagan type recurs with the estuarine and even open-sea type of sedimentation; each bed being accompanied by characteristic faunas. The Birrenswark Volcanic Zone, at the top of the Upper Old Red succession, is overlaid by the Whita Sandstones denoting shallow moving water. These are followed by a set of clays which alternate with limestones made up almost entirely of the brachiopod *Seminula* (*Camarophoria*) *crumena*, indicating comparatively clear water marine conditions. These beds are in turn succeeded by alternations of sandstones, clays and bands of lamellibranch limestone in which *Modiolas* like *M. macadami* or *Schizodus* are the only fossils, but some of the larger bands contain several species of lamellibranchs. *Spirorbis* limestones are also of constant recurrence among these sediments. Some of the calcareous sandstones are full of small Murchisonid gasteropods. Towards the top there are occurrences of limestone of a more marine character, and one of the calcareous clays contains numbers of the brachiopod *Syringothyris cuspidata*, which genus Vaughan uses as the characteristic form of his *Syringothyris* zone. Near the top of the group comes the Thorlieshope Limestone with a truly clear water marine fauna in which junciform *Lithostrotion*, several brachiopods, and other organisms are found.

Another limestone nearer the top of the group is entirely made up of the curious organism named by Nicholson *Micheldinia*, the exact nature of which is still problematical. One thing is certain, that it must have grown in water almost free from sediment. Estuarine conditions are shown towards the very top in the Tarras Water bed, yielding fishes and higher crustaceans.

¹ Tuedian Beds of Howse.

This type of sedimentation ceases in Liddisdale where it is succeeded by the Fell Sandstones, a group showing a rythmical alternation of massive sandstones, variegated clays, and coal seams, some of which are worked in the Plashetts Coal-field on the English side of the Border.

VULCANICITY DURING CEMENTSTONE TIMES.

The Upper Old Red volcanoes of the Merse and Liddisdale had become extinct before the close of that period. Farther to the north in East Lothian volcanic action broke out in Cementstone time, continued throughout the rest of that period and did not cease till the greater part of the succeeding group was deposited. Their ejectementa now form the Garleton Hills.

In Midlothian during this period, the Arthur's Seat volcano ran through all its phases, became extinct, and was buried up under the accumulating sediments of the group, and also the lavas and tuffs of smaller volcanoes that are now represented by Craiglockhart and Corston Hills. In the Campsie region volcanoes were almost continuously active throughout the whole period, and even on till Carboniferous Limestone time, giving rise to the great volcanic plateau which stretches from the Campsie and Kilpatrick Fells across the Clyde, there forming the Renfrewshire Heights. They also make up the great tableland separating the Clyde valley from the Ayrshire Lowlands. The eastward extension of the plateau is shown in the Cult Hills of Fife where it rises from under the Stirling and Clackmannan Coal-fields.

(b) THE OIL-SHALE GROUP.

The oil-shale type of sedimentation seems to have taken place within a very restricted area over what is now practically co-extensive with Mid and West Lothians and a small adjacent part of Fife. To the west, the area was held in by the accumulating volcanic rocks of the plateaus of Stirling, Dumbarton, and Lanarkshire, which there entirely replace the oil-shales. The remnant of the Southern Uplands that still stood above water, hemmed in these sediments towards the south-west, while, to the east and south lay the open sea, which periodically invaded the area as the land went down by small step-like movements. Estuarine conditions prevailed for the most part, but lagoons must have formed which were not often subjected to desiccation like those in which the cementstones were deposited. But there is evidence to show that they were sometimes so much flushed by rain as to become freshwater lakes. This seems to argue that a complete change of climate had been brought about by great earth movements somewhere outside the region at present under consideration.

Where the Oil-Shale Group of sediments attains its maximum in Mid and West Lothians it must be over 3000 feet thick. In this part of the region, according to Mr D. R. Steuart,¹ at least twenty seams of oil-shale have been worked in the 2500 feet of strata that separate the Pumpherston Shales, the lowest worked seam, up to the Raeburn Shale near the top of the group. But this does not exhaust the number as there are several thin, and at present unworkable, seams in the intervening strata; and still further beneath the Pumpherston horizon are the Dalmahoy Shales,² as well as several poor seams in the Wardie Shales, near the base of the group, where they crop out round about Edinburgh.

The massive Granton and Craigleith Sandstones, the equivalents of the Fell Sandstones of Liddisdale, form the natural base of the group, as they immediately overlie the Abbeyhill Shales, the highest members of the Cementstone Group in the Edinburgh district. The sandstones are overlaid by the well-known Wardie Shales, which, near their base, contain two coal seams that have been worked near Granton and are known as the Caroline Park seams. They also yield several poor oil-shales³ and ironstone nodules rich in fossil fishes, as well as two horizons of estuarine lamellibranch limestones. In turn they are succeeded by the Hailes Sandstone, the highest member of the group exposed in the neighbourhood of Edinburgh.

The strata between the Hailes beds and the Pumpherston Oil-Shales are not well known, but they contain the Dalmahoy Oil-Shale which is associated with an estuarine lamellibranch band. From the Pumpherston position upwards the details of the succession are well known. The first 500 feet consist of sandstones and shales with occasional seams of entomostracan limestone, the thickest and best known being the Burdiehouse Limestone which is accompanied above by the Raw Camps Oil-Shale. The strata intervening between this and the next workable group of oil-shales, known as the Dunnet Shales, are mainly made up of a thick sandstone, the Dunnet Sandstone. The lowest of these Dunnet seams is locally known as the Barracks Shale,⁴ and is underlaid by a bed of ash and a limestone of Burdiehouse type. The sandstones are succeeded by shales, marls and sandstones in which occur two or more oil-shales, the lowest being called the "Wee Dunnet" or Champfleurie Shale, and the upper seam or group of seams, the Broxburn Shales. These bands are overlain by a great thickness of the Broxburn Marls, grey mudstone-like beds with numerous bands of cementstone or limestone. To these strata succeed the

¹ "The Oil-Shales of the Lothians," *Mem. Geol. Sur.*, Second Edition, 1912, p. 142.

² *Ibid.* pp. 140-143.

³ "The Geology of the Neighbourhood of Edinburgh," *Mem. Geol. Sur.*, Second Edition, 1910, pp. 76, 77.

⁴ "The Oil-Shales of the Lothians," *Mem. Geol. Sur.*, Second Edition, 1912, p. 8.

Fells Oil-Shale separated from the Houston Coal above by about 300 feet of sandstone and shales. This coal seam was long ago extensively mined in West Lothian but is not at present considered worth exploiting. It is overlaid by the Houston Marls, a great thickness of clayey mudstones with calcareous and ferruginous bands. These marls, like those of Broxburn, are probably derived from the waste of basic volcanic rocks, and, indeed, the Houston Marls actually contain fragments of such rocks, as if they were in part volcanic tuffs. Above the marls comes the two-foot coal which is usually overlain almost immediately by a volcanic agglomerate. Two other oil-shale positions occur in the next few hundred feet—the lower is known as the Mungle Shale, that on the higher horizon is the Raeburn Shale position, in which there are two oil-shales, the upper being locally called the Fraser Shale, the highest worked oil-shale of the whole group which contains marine shells such as *Lingula*, orthoceratites and goniatites. Throughout the Oil-Shale field true clear-water marine organisms are rarely met with. At one horizon, however, the exact position of which is not accurately fixed, though it is below the Burdiehouse Limestone, a bed was discovered by Mr Macconochie, cropping out near Carlops, which has yielded a peculiar fauna of hinged brachiopods, *Productus* rhynchonellids, athyrids and hinged brachiopods and junciform *Lithostrotion*.¹ Bores, put down over the outcrop of the Burdiehouse or Raw Camps Limestone to the south of Harburn on the opposite side of the Pentlands from Carlops, tapped a band with encrinites and other marine forms which is probably on the same horizon.

Besides the horizons just mentioned where marine or estuarine forms occur, there is another very interesting bed a little below the Pumpherston Shale position to which it acts as a sure index, as pointed out by Mr Carruthers.² It contains goniatites, orthoceras and lamellibranchs, and a short distance beneath occurs a shrimp bed containing well-preserved crustacea of the genus *Tealliocaris*. Another marine bed occurs at Straiton in the Midlothian basin in the roof of one of the Dunnet Oil-Shales,³ which, in addition to containing orthoceratites, *Lingula*, and lamellibranchs, has yielded a large suite of fish remains, determined by Dr Traquair, and from which he considered that these fishes, and even those found in the Burdiehouse Limestone, were of estuarine habit.

With regard to the Burdiehouse Limestone being of freshwater origin,

¹ See remarks by Dr Lee in the Appendix to "Geology of the Neighbourhood of Edinburgh," *Mem. Geol. Sur.*, Second Edition, 1910, p. 370.

² "The Oil-Shales of the Lothians," *Mem. Geol. Sur.*, Second Edition, 1912, p. 10.

³ It is interesting to note, as Mr Carruthers informs me, that in the Main Oil-Shale Field to the west, a marine band with goniatites and lamellibranchs has recently been found to occur in the heart of the Dunnet Group of oil-shales.

Dr Hibbert, as far back as 1836 in his classical paper in the *Transactions* of the Royal Society of Edinburgh, called attention to the absence of marine forms; and from remains of land plants, entomostraca and fish, which occur so abundantly in it, he inferred that the limestone was of freshwater origin. In 1903 Dr Traquair, as already stated, from the large proportion of the fossil fishes common to that limestone and the Dunnet Shale, thought that it was probably estuarine. Since the publication of that paper, Dr F. D. Falconer obtained additional evidence bearing on the point. The Raw Camps or Burdiehouse Limestone is extensively mined in the neighbourhood of West Calder, where it contains chert in which Dr Falconer detected the Monactinellid sponge spicules of *Spongilla*. In the same bed with the cherts, stigmata roots are to be seen in the position in which they lived and died, thus affording strong presumptive evidence in favour of Hibbert's view. Moreover, among the fishes obtained from Burdiehouse the dipnoid fish *Uronemus*—a true “lung-fish”—is not uncommon in the Hugh Miller collection in the Royal Scottish Museum, Edinburgh.

DEPOSITION OF OIL-SHALES.

Mr Steuart, in his chapter on the chemistry of the oil-shales in the *Geological Survey Memoir* on “The Oil-Shales of the Lothians” (Second Edition, 1912), discusses their nature and origin. He shows that there is little bitumen or wax present in them as such, but that these substances are only developed by destructive distillation. It is therefore certain that they owe their nature to organic matter, but not from the decay of plant or animal matter leaving a residue of wax or fat. He further points out that some of the oil-shales are largely made up of entomostracan remains, so that he concludes that both plants and animals have entered into their composition. From conversations with him and a letter just received from him, I find that he is also of opinion that the volcanoes which were so active round about the oil-shale area, and within it, at several periods during the accumulation of the oil-shales, may have contributed towards their production by supplying warm water to the lagoons in which they accumulated, and in providing the waters with solutions which prevented the decay of the organic matter, and by periodic exhalations which poisoned and killed off the inhabitants of the lagoons.

These conclusions of Mr Steuart seem to me to be well substantiated by the study of the area under consideration. The oil-shales seem to have been deposited in quiet by-waters of river deltas or lagoons into which only the finest of sediment was carried, and that in very limited amount. In these waters a seasonal plankton of very lowly plant life appears to have arisen

which gave sustenance to innumerable swarms of entomostraca and other small animals that supported the smaller acipenseroid fishes which, in turn, supplied the food of the larger crossopterygian forms, as attested by the indigestible remains found in the coprolites that are of common occurrence in the Lothian Oil-Shales. Although the step-like depressions that the country was undergoing sometimes allowed the estuarine sea water to invade these lagoons and carry into them such marine forms as those associated with the Dalmahoy, Pumpherston, Dunnet, and Fraser Shales, it is not necessary to conclude that the whole fish fauna was of estuarine character. Lung-fishes of the genera *Uronemus* and *Otenodus* have left their remains with the oil-shale to attest to their freshwater origin. It is probable, therefore, that it is to the surplus of this lowly plant life that was not consumed by the animals that we must look for the main source of the hydrocarbons of the oil-shale, while the animal remains supplied the larger part of the nitrogenous matter. That the higher land vegetation surrounding the lagoons may have supplied a small amount of the material is just probable, but, if so, it must have been so well macerated by the water that the structures were so completely obliterated by decomposition brought about by the micro-organisms, as to leave no traces discoverable by the microscope. The beautiful state of preservation of such forms as *Telangium* (*Sphenopteris*) *affine* and *Lepidopholis* that are so common features in some of the oil-shales, militates strongly against such a supposition. The small—almost infinitesimal—remnant of material extractable by the ordinary solvents is greatly against the supposition that lycopodiaceous spores may have been swept into the lagoons after the manner of pollen during what are popularly known as “sulphur showers.” Mr Steuart says in his chapter that some oil-shales are largely made up of entomostraca. There is a regular passage of oil-shale into limestones of the Burdiehouse type, and every gradation can be found in the field. In the clear water parts of the lagoon where the entomostraca were able to dispose of the plankton as it arose, the constant accumulation of their exuviae and their shells, at death, would easily give rise to limestone of Burdiehouse type.

VULCANICITY DURING THE DEPOSITION OF THE OIL-SHALES.

As already stated there were two regions, one on each side of the Oil-Shale area, where volcanoes were active throughout the whole period of their production, viz. that of the Garleton Hills towards the east and of the Campsie Fells to the west. In both regions the volcanic plateau became subaerial and subject to atmospheric denudation. It is highly probable that these plateaux supplied material to form the peculiar mud-like clays with calcareous ribs that are known as the Marls, which occur along with the Houston Coal,

and the Broxburn and Dunnet Shales. The remains of less persistent and less extensive outbursts occur at several horizons within the Oil-Shale group. The lowest of these occurs within the Wardie Shales. A second forms an ash bed at the horizon of the Pumpherston Shales, a third is in connection with the Burdiehouse Limestone at Carlops, a fourth gives rise to the Barracks-ash lying between the oil-shale and the limestone of that name on the Dunnet horizon. As already stated there is evidence of volcanic ashes in connection with the Houston Marl. The agglomerate overlying the two-foot coal has been already mentioned, while near Linlithgow the place of the Mungles and Raeburn Shales must be occupied by lavas and ashes of the Bathgate Hills, where the volcanoes were active at intervals till well on into Carboniferous Limestone times.

This succession of local outbursts of vulcanicity within the area suggests the idea that it had some connection with the intermittent step-like settling of the ground. Whether that were so or not, there appears to be some association of these manifestations with horizons where crowds of exceptionally well-preserved higher crustacean and whole fish remains occur, viz. the Wardie Shales, the Pumpherston "shrimp bed," the Gullane fish and crustacean bed, which is a thin bed of black Carbonaceous Limestone in an impure oil-shale, from which complete specimens of *Tealliocaris* and fishes have been obtained.

On other horizons, the remains of fishes and crustacea are generally much broken up, and it is exceptional to find a whole fish, while there is usually evidence that the crustacea had been preyed upon. In the cases above mentioned it looks as if all the animals, captors and prey alike, had been suddenly killed, as if all had shared in the same catastrophe. Both the crustaceans and the fishes are fossilised in constrained attitudes suggesting that they met with a violent death. May this not have been caused by volcanic exhalations or poisonous waters impregnated with solutions derived from the soluble or unstable minerals of the ash showers or lava flows? The frequent association of ashes with the dark shales—impure oil-shales—gives colour to such a supposition. Moreover, such solutions would have a preservative action and help to mineralise the remains.

THE PETTYCUR POOL.

There is one clear case where the most delicate structures of plants have been preserved by such mineralisation. It has been long known that a limestone occurred among the volcanic rocks exposed on the shore between Pettycur and Burntisland, in which plant remains are so well preserved as to show their minute structures. The late Mr David Grieve, a former president

of this Society, made collections from it, and *Heterangium grievi*, a fern then new to science, commemorates his work there. The late C. W. Peach also worked in this bed, and obtained from it a lycopodiaceous cone, bearing both macrospores and microspores, which was described by the late Wm. Carruthers. In our own time the study of the contents of this bed has been taken up with great success by Dr Gordon, who has been enabled to throw much light upon the methods that many of the early plants adopted in building up trunks and branches, which enabled otherwise lowly and creeping plants to assume tree-like habits, and thus to outstrip their neighbours in the struggle for light and for air. Dr Gordon was fortunate enough to be able to trace this rock to its source among the volcanic pile in Alexander's Crag. He considers that the limestone, although now broken up and included in a volcanic breccia, must have been formed in a freshwater pool in the volcanic plateau, which must at that time have become subaerial. Into this pool the Upland vegetation growing upon the rich volcanic soil afforded by the very basic rocks of the plateau must have fallen, and the spring water supplied by these rocks was so full of mineralising matter as to replace the finest structures, molecule by molecule, as they decayed. The remains of such a pool are well shown in section on the seashore close by; for, overlying the slaggy top of a very basic lava and filling up all the cracks and inequalities of the floors, a few feet of dark almost black shale and limestone with plant remains are seen to be overlaid by a second lava stream, the base of which is perforated vertically upwards for a foot or more by a succession of cylindrical vesicles where the steam from the wet sediments must have risen through the still liquid lava. Farther to the east of Pettycur harbour, and north of the street, black shales occur between the flows in which Dr Gordon obtained some well-preserved stems, and a little farther still, above another flow, two coal seams are seen to crop out among fine tuffs.

That an upland flora existed is shown by the well-known example of the tree trunk *Pitys (Araucarioxylon) withami*, found in the Craigeleith Quarry, which passed up obliquely through many feet of sandstone and which must have been a veritable "Sawyer," pictures of which are familiar to us.

Each volcanic cone that rose above water seems to have harboured a small colony of stem-forming plants. This is indicated by the common occurrence of charred and mineralised fragments of wood to be met with among the agglomerates and other debris which fill in the underground vents or "necks" now exposed by denudation, often where the whole of the ejectamenta cast out upon the original surface has been swept away. Professor Judd, Mr A. Macconochie, and more recently Dr Campbell obtained such woody fragments in the Lion's Head vent of Arthur's Seat.

THE OIL-SHALE GROUP IN EAST FIFE.

The rocks which represent this group are nowhere better displayed than on the coast of East Fife. Thanks to the splendid work of the late J. W. Kirkby the best and most continuous section, viz., that exposed on the shore between Pittenweem and Anstruther, has been minutely studied and recorded in great detail. The results of his work were generously handed over to the Geological Survey, and published by Sir Archibald Geikie in his account of the Geology of East Fife.

In Mr Kirkby's detailed section, Bed No. 52 may be taken as the top of the Oil-Shale group, while Bed 648—the Billow Ness Sandstone—may be regarded as the equivalent of the Granton Sandstone, the base of the group. The measured section thus shows a thickness of nearly 3000 feet of strata. Beds 534-536, lying about 220 feet above the base, may be considered to represent the Burdiehouse Limestone, but this is the only horizon that can with any degree of certainty be correlated with those of the Lothian basin.

Among the rocks which occupy the shore between Billow Ness and Bed 536, there are several occurrences of entomostracan limestone of Burdiehouse type which yield remains of the familiar fish fauna of the oil-shales, but there are also many more evidences of beds bearing estuarine lamellibranchs. In addition there are about ten coal seams, each sitting upon its fireclay with rootlets, marking at least so many recurrences of land conditions. Above the Burdiehouse Limestone a similar type of sediment is met with, denoting a constant alternation of land surfaces, marked by thin coals and fireclays, and estuarine conditions shown by shales and limestones containing an estuarine or marine fauna. At 295 feet above the Burdiehouse Limestone occurs Bed No. 506, named by the Rev. Thomas Brown the "Encrinite Bed," which contains a considerable number of clear-water marine forms—hinged brachiopods, crinoids, and junciform *Lithostroton*—showing that the bed is within Vaughan's zone of *Dibunophyllum*. In the next 1826 feet of strata, there are sixteen coal seams and one parrot coal. There is an almost complete absence of shales and limestones with marine and estuarine forms, and the conditions of deposit seem to be like that of the Edge Coals. Although the Abden Limestones have been included in the Calciferous Sandstone series by the Geological Survey, they may be much more naturally classed with the overlying Carboniferous Limestones, the conditions of their deposit being identical with those of the Lower Limestone Group.

EAST LoTHIAN.

The conditions of deposit during the Oil-Shale group in East Lothian are much like those of East Fife, showing that the area was under the same

physical conditions. Two distinctly marine beds crop out on the shore at Cockburnspath above the great series of sandstones with which the Scremerston Coals are associated. An oil-shale also occurs on the shore north of Cove Harbour which is well known in the Scremerston district.

LIDDISDALE.

The Fell Sandstones, representing the beginning of the period, can be traced westwards through Woodcock Air to the sea south of Criffel, where they are succeeded by alternations of truly marine limestones with shales, sandstones and coal seams. A volcanic zone occurs just over the top of the Fell Sandstones which can be traced from Langholm throughout the Larriston Fells. The famous Langholm "scorpion bed" occurs within this zone, and represents a salt-water lagoon with an estuarine lamellibranch fauna. The whole crustacea and fishes so well preserved may have been asphyxiated by volcanic exhalations. Interstratified with the ash which accompanies it, there is a thin bed of oil-shale and black chert. The silica of the chert is in all probability a diatom deposit due to the water being impregnated with soluble silicates from the tuff. The Fell Sandstones are overlaid by the Scremerston and Lowick coal-bearing rocks consisting of sandstones, shales, fireclay, coals, and thick beds of truly marine limestones the continuations of the same zones as those of Plashetts. It is evident that along this line we have the edge of the great sea in which the lower members of the Yoredale rocks of the North of England and the Carboniferous Limestone farther to the south were deposited, the conditions of deposit being exactly similar to that to be described.

CARBONIFEROUS LIMESTONE OF SCOTLAND.

During the deposition of the lower portion of the Carboniferous Limestone series, marine conditions similar to those existing in Liddisdale had crept northwards over nearly the whole of the East of Scotland, the only parts escaping being some small islands in what are now the Southern Uplands.

Over the whole area the conditions were wonderfully alike. The series of deposits can be broken up into three groups, viz. (a) A Lower Limestone group; (b) Middle Coal and Ironstone group; and (c) Upper Limestone group.

The lowest limestones are well within the *Dibunophyllum* zone of Vaughan's succession, while the upper limestones may represent part of the Millstone Grit of England.

In the Lower group there is a well-marked rhythm in the sedimentation, doubtless marking successive pauses in the general movement of depression of the area. When the cycle is complete, a coal seam, marking a land

surface, is succeeded by a limestone, denoting a depression which has changed the land surface into the bed of a clear sea. The limestone is followed by calcareous shales which give place to mixed muddy and sandy deposits and at length to sandstone. To show that the shallow sea has been filled up to the brim, the sandstone is usually overlaid by fireclay or ganister full of roots, and, in turn, by a coal seam representing the rooted vegetation of a land surface. The cycle, however, may be arrested at any point owing to minor subsidences with shorter intervals of time. A constant recurrence of such cycles shows that the land surfaces must have had a very gentle slope seawards so that a small vertical downward movement, such as that indicated by the short distances between two limestones overlying coals, was sufficient to carry what was a land surface far enough from shore to be beyond the reach of terrigenous sediment. The complete cycle has taken place more than once among the Lower Limestone group, in which is included the Abden Limestones which are generally classed as the upper members of the underlying Oil-Shale group.

The Middle group, which is the great source of mineral wealth of Scotland, and more extensive than that of the true Coal Measures, shows incomplete cycles where the depressions are never sufficient to carry the land surface sufficiently far out to sea to produce limestones, although shales with marine organisms and estuarine beds occur at one or two horizons. There are in some of the coal-fields of the middle division in the present area nearly a hundred coal seams, but perhaps only a score of them have been exploited, the others being too thin to work hitherto.

In the Upper Limestone group, about 600-700 feet thick in the Lothians, the cycle is more often completed: limestones with true marine fossils recur at least four times, and there are several workable coal seams.

From what has been said above it will be seen that the East of Scotland is most favourably situated for studying the local migration of the organisms due to the constant change of conditions. Each kind of sediment has its characteristic group of fossils whether of marine, estuarine, freshwater, or land surface type.

On studying the mode of occurrence of the organisms to be found in these beds, it soon becomes apparent that each different phase of sediment entombs its peculiar fauna, which continually recurs with it at all levels. From the study of the fish fauna the late Dr Traquair pointed out that black shales, gas coal, black-band ironstone, and certain entomostracan limestones, sediments that pass insensibly into one another and yield *Lingula*, ostracods, and estuarine lamellibranchs, contained the same distinct fish fauna of estuarine character at all levels in the series. This fauna differs radically

from another set of fishes that as persistently accompany the recurrences of marine limestones. A similar story is told by the corals, brachiopods and other marine forms. The sandstones are singularly devoid of organisms beyond worm-casts and trails, while the fireclays are always traversed by rootlets. In the case of the limestones, the more muddy portions carry a different fauna from the purer limestones. This is well illustrated by the association of fossils found in the sediments underlying the first Abden Limestone at its outcrop near Kinghorn. Succeeding a basalt lava are 3 feet of dark shale near the base of which occurs an inch or so of dark "bone-bed" in which the fish remains are all fragmentary and mixed up with broken *Lingulas*. Above the "bone-bed" the shale contains *Naiadites*, *Pterinopecten*, *Actinopteria* (*Pteronites*) and *Sanguinolites abdenensis*. The shale is overlaid by 18 inches of marly clay with plants, and this in turn by 18 inches of dark shale with foraminifera, ostracods, *Lingula*, *Productus*, *Pterinopecten*, *Naiadites* (*Myalina*), *Actinopteria* (*Pteronites*), *Sanguinolites abdenensis*. This is overlaid by 6 feet of green tuff above which is 1 foot of shale with limestone nodules which yield, in addition to foraminifera and entomostraca, the brachiopods, *Schizophoria* (*Orthis*) *resupinata*, and *Ripidomella* (*Orthis*) *michelini*, *Chonetes*, *Spirifer*, and *Archæocidaris*. Above is 10 feet of limestone somewhat calmy in character containing a marine facies of fossils including *Lithostrotion*, several crinoids, rhynchonellids, *Spirifer* and orthotetids.

A similar "bone-bed" overlaid by a limestone with *Ripidomella* and *Schizophoria* which underlies a twenty-foot thick limestone, was discovered by Mr Macconochie at the junction of a tributary with the Bilston Burn, on the western side of the Midlothian Coal-field, as recorded in the Edinburgh Memoir of the Geological Survey, p. 162. The "bone-bed" there contains broken-up *Lingulae* and fish bones as at Abden. Since the memoir was written, Mr A. Macconochie, at the instigation of Mr Peter Macnair, has unearthed a lamellibranch fauna from the thin layers that separate the bone-bed from the *Ripidomella* layer. This fauna contains *Sanguinolites abdenensis*. The fish-bed has also been identified in the Gilmerton section, thus furnishing a close correlation with that of the Bilston Burn (see p. 170, Edin. Memoir).

Mr Peter Macnair, in his paper on the Hurlet Sequence in Ayrshire, read before the Geological Society of Glasgow on the 9th May of last year, shows the occurrence of a bone-bed identical in character with that of Abden and Bilston Burn, and like them followed by lamellibranch bearing shales containing *Myalina vernueili*, *Sanguinolites abdenensis*, *Actinopteria* (*Pteronites*) *persulcata*, *Streblopteria* (*Aviculopecten*) *ornata*, succeeded by beds yielding *Ripidomella* (*Orthis*) *michelini* and *Schizophoria* (*Orthis*) *resupinata*. This sequence forms a constant horizon between the Hurlet Coal and the Hurlet

Limestone of the West of Scotland. The beds containing this succession of faunas in such small thickness constitute the well-known Alum Shale which was formerly so extensively worked in the Campsie district. If Mr Macnair establishes his contention that these three successive faunas are confined to this horizon, it will afford a splendid datum line for correlating the beds in East and West Scotland.

Dr Crampton has identified the first Abden Limestone with the Long Craig Limestone of Aberlady and Dunbar.

Another interesting study can be made of a peculiar succession of beds, where, in the short compass of about 10 feet of strata, there is represented the phases of a passage from a land surface to clear sea conditions. The section occurs where the second Abden Limestone crops out on the Fife shore, east of Kinghorn. Overlying the last of the basalt lava flows of the Burntisland volcanic plateau is a bed of ash or tuff, which, near its top, contains well-preserved fronds of *Rachopteris duplex* almost perfect, doubtless trapped either upon or near a land surface. The ash towards its top assumes the appearance of one of the oil-shale "Marls" and passes upwards into a fireclay. This is succeeded by a band about an inch thick, crammed with the large and strong shells of *Naiadites (Myalina) crassa*, an estuarine form. The shell bed is succeeded by about 4 feet of hard black shale which contains, in addition to *Naiadites*, *Bellerophon* and *Orthoceras*, indicating more saline conditions. The next 4 feet of blue calcareous shale is crowded with *Productus longispinus*, orthids, aviculopectens, *Lingula*, *Orbiculoidea*, *Nucula* and *Macrochilina*, as well as debris of crinoids, marking a distinctly marine though muddy condition. Above comes the main mass of the second Abden Limestone, about 14 feet thick, a white limestone almost free from terrigenous sediment, arranged in layers, from about a foot to less than an inch in thickness, marking a clear sea deposit formed from organic remains only. The organisms themselves are assorted in distinct colonies or layers and do not occur promiscuously throughout the limestone. Near the base are found *Productus*, crinoids, and simple corals. Above this, there are lines of reef-building colonies of *Lithostrotion junceum* and *L. irregulare* and matted masses of *Stenopora (Chonetes)*. Towards the middle of the band there are thin flags made up almost entirely of the broken-up plates, spines, and lanterns of *Archaeocidaris*, and, near the top of the seam, bands of more muddy limestone with debris of encrinites alternate with the flaggy white layers, as if sediments were being pushed out from the land and were invading the former clear sea. In the 100 feet of sediments which separate this band from the overlying Seafeld Tower or Inveriel Limestone there are two seams of coal, a fact which would seem to indicate that the second Abden

seam had accumulated under less than 100 feet of water, and to show how small a subsidence could carry a widespread land surface so far from the shore as to be practically beyond the reach of land-derived sediment.

Mr James Wright, who has made a special study of the disposition of the crinoid remains in the shales overlying the Inverteil Limestone to the west of Kirkcaldy, divides the shales into three beds each containing a somewhat different crinoid fauna.¹ This fact he is inclined to attribute to "the dying out, or perhaps migration, of certain species at different times, and the incoming of others as conditions became favourable for crinoid life."

DWARFED FORMS.

It has long been known that many of the marine forms common to the Carboniferous Limestones of England and Scotland are dwarfed in Scotland compared with those in England, as if the conditions here had not been congenial to their mode of life. This is doubtless due to lesser salinity, admixture of sediments, and nearness to shore conditions of deposit. There is even a striking difference in the size of the same species of brachiopod shells collected from the same limestone seams near the two ends of the Midlothian basin. Those from the quarries at the south end are markedly larger than those from the north end, and are easily distinguishable from each other. The reason seems to be, that although our individual limestones are very widespread and extend over nearly the whole Midland area, yet our fine sediments seem to have come from the north and west as if they were discharged from some mighty river, while the coast-lines of the island represented by our Southern Uplands to the south of the Midlothian Coal-field, seem to have afforded coarse sediments only which were deposited close inshore leaving a strip of clearer water between them and the muddy water from the river. In support of this view it is quite noticeable that, as the southern part of the Midland Carboniferous area is approached, the limestones become more numerous and individually thicker.

ABSENCE OF LAMELLIBRANCH SHELLS FROM THE CARBONIFEROUS SANDSTONES.

One is struck with the almost entire absence of lamellibranch shells from the Carboniferous sandstones. This cannot be due to their remains having been dissolved out by passage of water through these permeable strata; for, had they inhabited the sands in the manner of our present myas, solens, cockles, and such sand-loving forms, their casts, or at least their burrows would still be apparent, as the sandstones are sometimes found riddled with

¹ *Trans. Edin. Geol. Soc.* (1914), vol. x., part ii., p. 159.

burrows of the much more perishable annelids and other soft-bodied animals. The question suggests itself as to whether calcareous lamellibranchs had as yet adapted themselves to such a life by producing structures that would allow of the habit. The only examples I have observed of the casts of lamellibranchs in sandstone have been detached valves of such flattened forms as *Aviculopectens*, and these were lying along the bedding planes in such a manner as to show plainly that they had been carried there after death. This evidence, though negative, is in accordance with the fact that no pallial sinus has been observed in a Carboniferous lamellibranch.

EXPANSION IN CALCAREOUS SEDIMENTS.

In working over sections of the Carboniferous as well as other formations where calcareous rocks alternate with shales or sandstones, one can hardly fail to see that the calcareous bands are more or less folded independently of the adjacent layers. Often, as is well displayed in the old railway cutting at South Queensferry, the calcareous beds associated with dark sandy shales are overfolded and even overthrust upon themselves at almost regular short intervals, and often staved together and brecciated without a corresponding disturbance being visible in the shales. The limestone beds exposed on the shore at Skateraw and Long Craigs, south of Dunbar, are thrown into innumerable small domes and basins. In the successive beds of the Hosies Limestones, which form strips parallel with the coast-line on the wave-eroded shore to the south of Seafield Tower near Kirkcaldy, each band of limestone in turn is seen to be traversed at regular intervals of about 20 yards or so by very oblique upthrust faults showing displacements of several feet, sometimes in one direction and sometimes in the opposite one, but none of these thrust planes go far up or down into the adjacent strata. One cannot but see that in all the cases these beds have been subjected to lateral thrust after consolidation. It is also plain that the force which produced the tangential thrusting must have developed within the limestones themselves. The study of calcareous strata almost everywhere shows that limestones and clay ironstones set or become solid at or near the surface of accumulation. Most of these limestones are of organic origin, and aragonite, the densest and heaviest form of calcium carbonate, enters very largely into the skeletons of calcareous organisms. During the process of setting, aragonite, which is markedly unstable, in changing into the stable but more bulky calcite, may have supplied the necessary tangential pressure. In many cases, in every formation studied by me from the Cambrian limestones up to the Carboniferous Limestone, breccias of the broken-up layers of limestone have been observed where limestone of the same type as the brecciated fragments

fills in the interspaces, showing that the breaking-up and healing must have taken place while deposition was still proceeding. May not this expansion, due to setting, be sufficient to account for the initiation of "Reef Knolls" so common among the larger masses of Carboniferous Limestone, such as are met with in England and the Isle of Man. By this method the reef-building organisms would obtain hard surfaces to which they could attach themselves and thus increase the "Knoll." A "Reef Knoll" on a small scale is seen in one of the quarries at Roscobie in Fife.

MILLSTONE GRIT.

The Millstone Grit of this region is built up of a succession of sandstones, shales, fireclays, thin cementstone or cementstone bands and a few thin coals. Calcareous sandstones are its chief feature and give rise to barren country, hence the Scottish name of the "Moor Rock," popularly applied to it in the West of Scotland, and the "Roslyn Sandstone" in the Midlothian Coal-field.

The Scottish Millstone Grit may be divided into two nearly equal groups, the Lower containing the rocks which show recurrences of cementstone or limestone with marine fossils, and an Upper Group from which they are absent.

In the area under consideration the beds of the whole series are conformable to one another throughout, and show nothing to account for the profound Palæontological break which occurs at or near the division line of the two groups. Dr Kidston has shown that only one or two species of plants pass across this line either up or down. Dr Traquair has for a longer time drawn attention to a similar state of matters with regard to the species of fishes, especially of those of estuarine habit. The forms beneath seem to come up through all the lower subdivisions of the Carboniferous rocks, but do not cross the line, while those above it pass on up through the Coal Measures. From these facts the line has come to be considered, not only a dividing one for the Millstone Grit, but also that between the Lower and Upper Carboniferous rocks. As the rocks afford no sign of physical break in the region under consideration, some great physical change must have taken place outside it, to account for this almost complete replacement of the flora and fish fauna by others. Change of climate alone seems powerless to bring about so sudden a revulsion.

As to the conditions of deposit in the lower half of the Millstone Grit, we find that the cementstone bands hold a marine fauna similar to that which is found in the upper limestones of the underlying Carboniferous Limestone Series, while the sandstones and fireclays are of much the same nature as those found between the limestones and coals of that series, with

similar rhythmic cycles of deposition, though few traces of land surfaces are recorded.

NEBRASKAN FAUNA.

While the revision of the Lothian and Stirlingshire Coal-fields by the Geological Survey was proceeding, Mr D. Tait discovered that the dark shales and the cementstone bands held a peculiar, and to him, unfamiliar facies of lamellibranchs, brachiopods and gasteropods. These were submitted to Dr Wheelton Hind, who showed that this facies, although it was unknown in Britain, had already been described from the Coal Measures of Nebraska and Illinois, in North America. In 1905 he gave the first preliminary notice of the discovery, and in 1908 he described the lamellibranchs and gasteropods before the Royal Society of Edinburgh. Some of the lamellibranchs were known to occur in Permo-Carboniferous rocks in Russia, and at first it was thought that the find was that of a colony caught in the act of migration from America to Europe. Against this view, however, is the fact that the late James Thomson of Glasgow had recorded some of the forms as occurring in the lower limestones of Tirfergus Glen near Campbeltown. Later discovery of some of the forms in the Index Limestone position found in cores of bores put down in the Carse of Stirling, from the Calciferous Sandstone Series at Arbigland by Mr John Smith, and from the Lower Limestone Group in Fife by Mr James Wright, of Kirkcaldy, tend to show that they must have been permanent somewhere near our area and only occasionally migrated into it as conditions became favourable. One point, however, is strongly brought out by this discovery, that the forms must have been dispersed along shore lines which extended from European Russia to America across what is now the Atlantic Ocean.

The peculiar assemblage of fossils that characterise Dr Hind's Pendleside group, and which, he thinks, marks a distinctive zone somewhere about the horizon of the Millstone Grit, have been found at much lower horizons in the West of Scotland. Some of these are recorded by Mr J. Neilson from the Orchard Limestone, one of the Upper Limestone Group, and also from the Calderwood Cement, belonging to the Lower Limestone Group, enclosed in sediments similar to that in which they are embedded in Dr Hind's type area. Mr James Wright of Kirkcaldy records *Posidonomya becheri*, one of the characteristic Pendleside forms, from a still lower horizon in Fife, viz. that of the Abden Limestones. These facts seem also to show that the assemblage is one which naturally associates itself with some particular type of sedimentation where, if accumulation is just keeping pace with depression, it may continue to live on; but is ousted from areas where

either depression or more rapid accumulation necessitates short migrations to a congenial habitat to escape extinction.

The upper half of the Millstone Grit shows partial cycles of deposition of grit, fireclays, ganisters, and sometimes even thin coal seams. As already stated its fossils are of Coal Measure type.

COAL MEASURES.

The Coal Measures in our area are divisible into three groups.

Lower Coal Measures.—The Lower Coal Measures consist of white and yellow sandstones, shales, fireclays, coals and ironstones, and attain a thickness of about 600 or 700 feet.

These materials show a rythmical cycle of deposition, which, throughout the greater part of the column, does not indicate any truly marine or even estuarine conditions. This indicates that depression was still proceeding by irregular short steps. In the case of the eight-foot coal, however, the late Mr Kirkby records the presence of *Anthracomya wardi*, *Naiadites* (*Anthracoptera*) *carinata*, *Carbonia fabulina*, and *Spirorbis pusillus* (*carbonarius*) from its roof, which indicates a depression bringing on estuarine conditions over a land surface. He also records plant remains encrusted with *Spirorbis* from the roof of one of the other seams showing a similar transition. For the most part, the lamellibranchs that are found in the shales often overlying the coal seams belong to the genus *Carbonicola*, formerly named *Anthracosia*, one of the family Unionidæ of freshwater habit.

At or near the top of the group, a thin bed of calcareous shale with truly marine forms, known as "Skipsey's Band," occurs throughout the Midland Scottish Coal-fields, and this in Midlothian has yielded *Spirifer*, *Chonetes*, *Productus longispinus*, and nautiloids, denoting a widespread and more pronounced depression of the whole of Southern Scotland which brought in marine conditions for a short time over the flat delta of some great continental river or rivers.

The vegetation of the Lower Coal Measures group is so distinctive that Dr Kidston has arranged the strata under a special division named by him "Lanarkian."

Middle Coal Measures.—Overlying the dark productive rocks above mentioned comes a series of red sandstones, shales, marls and calcareous bands, with only a few thin coal-seams. Owing to denudation, comparatively small outliers detached from each other are left. In the Midlothian outlier, at about 230 feet up from the marine band at the top of the Lower group, another thin estuarine or marine band occurs which has yielded *Lingula*, *Productus*, a pectiniform lamellibranch, and a nautiloid shell. In the Fife

outlier, the largest of them, Mr Kirkby obtained *Leaia leydii*, *Carbonia rankiniana*, and *Spirorbis carbonarius* from the roof of one of two thin coals, indicating a slightly brackish-water condition. The evidence afforded by the rest of the rocks is scanty, but it seems to denote land and freshwater conditions.

In the Canonbie or Solway region, the Middle Coal Measures contain some workable coals which were formerly wrought under the name of the "Byreburn Coals," and associated with them in the River Esk sections are mussel bands made up of the freshwater *Carbonicola*. No marine bands are recorded from these beds, which are not red in colour, though they carry the distinctive Middle Coal Measure plants as shown by Dr Kidston.

Upper Coal Measures.—In the Canonbie region a set of red sandstones, fireclays, and a few coal seams have yielded a suite of plant remains which have been shown by Dr Kidston to be like those from the Radstock coal-field, indicating that they must be classed with the Upper Coal Measures.

Nowhere in Scotland is the top of the Coal Measures reached. Their relation to any Permian rocks is one of violent unconformability indicated by the overlap of the Permian and Triassic rocks of the Solway region over the denuded edges of all the Carboniferous rocks till they come to rest on the Silurian greywackes of the Southern Uplands.

From evidence obtained during the revision of the Lanarkshire and Ayrshire Coal-fields by the Geological Survey, Dr Kidston is at present doubtful as to the exact line of division between his Lower and Middle Scottish Coal Measures. He finds that some of the Middle Coal Measure plants that he relied upon for his classification have been found to occur below the line at present adopted, so that part of our Lower Coal Measures may be on the same horizon as rocks that are elsewhere classified with the Middle Coal Measures.

JOURNAL OF PROCEEDINGS.

OCTOBER 1912 — MARCH 1915.

SESSION CXLII.

Monday, 28th October 1912.—Professor J. ARTHUR THOMSON, M.A.,
President, in the Chair.

Professor Thomson, whose term as President had expired, delivered an address upon “HENRI BERGSON’S BIOLOGY.”

Monday, 25th November 1912.—J. H. ASHWORTH, Esq., D.Sc.,
in the Chair.

The Annual Reports of the Secretary, Librarian, and Treasurer were submitted.

The following Office-Bearers for the Session were elected :

President—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E.

Vice-Presidents—Professor E. A. SCHÄFER, LL.D., F.R.S.; B. N. PEACH, Esq., LL.D., F.R.S., F.G.S.; WM. EVANS, Esq., F.F.A., F.R.S.E.

Secretary—W. F. P. M’LINTOCK, Esq., B.Sc.

Assistant-Secretary—D. C. M’INTOSH, Esq., M.A., D.Sc., F.R.S.E.

Treasurer—WM. WILLIAMSON, Esq., F.R.S.E.

Librarian—PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.

Councillors—Professor ARTHUR ROBINSON, M.D.; E. B. JAMIESON, Esq., M.D.; Professor L. A. L. KING, M.A.; J. H. ASHWORTH, Esq., D.Sc.; Professor D’ARCY W. THOMPSON, C.B., B.A.; WM. S. BRUCE, Esq., LL.D., F.R.S.E.; W. E. AGAR, Esq., B.A., D.Sc.; Professor J. ARTHUR THOMSON, M.A., F.R.S.E.; LIONEL W. HINXMAN, Esq., B.A., F.R.S.E.; JAMES RITCHIE, Esq., M.A., D.Sc.; THEODORE RETTIE, Esq., D.Sc.; SYMINGTON GRIEVE, Esq.

A resolution expressing regret at the death of Ramsay Heatley Traquair, Esq., M.D., LL.D., F.R.S., was adopted.

The following Communications were submitted :

1. Note on the Type Specimens of the Hydroid Zoophyte, *Plumularia catharina*, Johnston; and
2. On the Invalidity of the Hydroid Genus, *Diplopteron*, Allman. By JAMES RITCHIE, Esq., M.A., D.Sc.
3. Note on *Chiastopsylla*, Rothsch., a genus of Siphonaptera, with Description of a New Species (*C. godfreyi*); and
4. A New Species of *Ischnopsyllus* (*I. ashworthii*) parasitic upon the Cape Horse-shoe Bat (*Rhinolophus auror*). By Rev. JAMES WATERSTON, B.D., B.Sc. (Communicated by J. H. ASHWORTH, Esq., D.Sc.)
5. Exhibition of Living Specimens of rare Insects and Ticks. By J. H. ASHWORTH, Esq., D.Sc.
6. Exhibition of a rare and curious Mantid, *Gongylus gonyioides*, from Ceylon. By WM. EVANS, Esq., F.F.A., F.R.S.E.
7. Exhibition of rare Corals from the margin of the British Area. By JAMES RITCHIE, Esq., M.A., D.Sc.

Monday, 16th December 1912.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc.,
F.R.S.E., President, in the Chair.

The following were elected Ordinary Fellows of the Society:—Miss Margaret Colley March, M.Sc.(Man.); G. G. Blackwood, Esq., F.F.A.; Malcolm Laurie, Esq., B.A., D.Sc.; and Rev. James Waterston, B.D., B.Sc.

The following Communications were submitted:

1. On Siphonophora of the Scottish National Antarctic Expedition. By J. KOETPERN, Esq.
 2. Exhibition of Model of Carapace and Hypostome of a Trilobite (*Calymene*). By MALCOLM LAURIE, Esq., B.A., D.Sc.
 3. Exhibition of Lantern Slides of Minerals, taken in Natural Colours. By the SECRETARY.
 4. Exhibition of Lantern Slides of Butterflies, taken in Natural Colours. By PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.
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Monday, 27th January 1913.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc.,
F.R.S.E., President, in the Chair.

Jas. A. S. Watson, B.Sc., F.R.S.E., was elected an Ordinary Fellow.

The following Communications were submitted:

1. On *Thanasimus rufipes*, a Beetle new to the British fauna, and its Life-History; with exhibition of specimens. By Professor T. HUDSON BEARE, B.A., B.Sc., M.Inst.C.E.
 2. A Lantern Demonstration on a Series of Composite Organs in Duplicity and Triplicity among Fishes. By J. F. GEMMILL, Esq., M.A., M.D., D.Sc.
 3. Ecology, the best method of studying the Distribution of Species in Great Britain. By C. B. CRAMPTON, Esq., M.B., C.M.
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Monday, 24th February 1913.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc.,
F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows:—Sydney E. Brock, Esq., and Andrew Watt, Esq., M.A., F.R.S.E.

The Communications submitted were as follows:

1. Demonstration on some Old Peruvian Skulls. By Principal J. YULE MACKAY, M.D., LL.D.
 2. Note on the Morphology of the Heart in Vertebrates. By Professor J. GRAHAM KERR, M.A., F.R.S.
 3. An Experiment on the Transmission of Environmental Effects. By W. E. AGAR, B.A., D.Sc.
 4. Fishes of St Helena, collected by the Scottish National Antarctic Expedition. By R. S. Clark, Esq., B.Sc.
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Monday, 24th March 1913.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc.,
F.R.S.E., President, in the Chair.

The following gentlemen were elected to be Ordinary Fellows:—C. Hawker Dinham, Esq., B.A., F.G.S.; William Dawson Henderson, Esq., M.A., B.Sc., Ph.D., F.R.S.E.; Murray Macgregor, Esq., B.Sc.; J. E. Richey, Esq., B.A.

The Communications submitted were :

1. Obituary Notice of Ramsay Heatley Traquair, Esq., M.D., LL.D., F.R.S. By PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.
2. Observations on some rare New Zealand Birds, with exhibition of specimens. By SYMINGTON GRIEVE, Esq.
3. On Mitosis in *Amoeba proteus*. By Miss L. A. CARTER. (Communicated by JAMES RITCHIE, Esq., M.A., D.Sc.)
4. Some Carboniferous Arthropods ; and
5. Exhibition of Model of the Eurypterid, *Stimonia acuminata*. By B. N. PEACH, Esq., LL.D., F.R.S.
6. A List of Anoplura obtained in the Forth Area. By Wm. EVANS, Esq., F.F.A., F.R.S.E.

SESSION CXLIII.

Monday, 27th October 1913.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

There was elected as an Ordinary Fellow of the Society, Eugene Gumpert, Esq.

The following Communications were submitted :—

1. Exhibition of 30 Cuckoos' Eggs and Foster Clutches, with observations on the colour of the former. By J. RENNIE, Esq., D.Sc.
2. Exhibition of preparation of Fisherman's Lugworm (*Arenicola marina*) in its natural habitat. By JAMES RITCHIE, Esq., M.A., D.Sc.
3. Exhibition of Nest of Solitary Wasp, from British Columbia. By T. B. SPRAGUE, Esq., M.A., LL.D., F.R.S.E.

Monday, 24th November 1913.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following were elected Ordinary Fellows of the Society :—T. H. Gillespie, Esq., and L. N. G. Ramsay, Esq., M.A., B.Sc.

Annual Reports were submitted by the Secretary on behalf of the Council, by the Treasurer, and by the Librarian.

The following Office-Bearers for the Session were elected :—

President—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E.

Vice-Presidents—B. N. PEACH, Esq., LL.D., F.R.S.; Wm. EVANS, Esq., F.F.A., F.R.S.E.; and Professor ARTHUR ROBINSON, M.D.

Secretary—JAMES RITCHIE, Esq., M.A., D.Sc.

Assistant-Secretary—JAMES A. S. WATSON, Esq., B.Sc., F.R.S.E.

Treasurer—WILLIAM WILLIAMSON, Esq., F.R.S.E.

Librarian—PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.

Councillors—Professor D'ARCY W. THOMPSON, C.B., B.A.; Wm. S. BRUCE, Esq., LL.D., F.R.S.E.; W. E. AGAR, Esq., B.A., D.Sc.; Professor J. ARTHUR THOMSON, M.A., F.R.S.E.; LIONEL W. HINXMAN, Esq., B.A.; THEODORE RETTIE, Esq., D.Sc.; SYMINGTON GRIEVE, Esq.; Professor J. COSSAR EWART, M.D., F.R.S.; HUGH MILLER, Esq., F.Z.S.; MALCOLM LAURIE, Esq., B.A., D.Sc.; W. F. P. M'LINTOCK, Esq., B.Sc.; and J. KIRKE NASH, Esq., L.D.S.Ed.

The following Communications were submitted :

1. A Contribution to the Spider Fauna of Scotland. By A. RANDELL JACKSON, Esq., M.D., D.Sc. (Communicated by WM. EVANS, Esq., F.F.A., F.R.S.E.)
 2. Exhibition of Nymph-Skin and Imago of *Oncotympana obnubila*, Distant, a species of Cicada from India. By PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.
 3. Notes on some Littoral Mites of Millport, with exhibition of specimens. By Professor L. A. L. KING, M.A.
 4. Exhibition of Insects collected on the Isle of May; (1) Lepidoptera. By WM. EVANS, Esq., F.F.A., F.R.S.E.
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Monday, 15th December 1913.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following Communications were submitted :

1. Note on the supposed Hypodermic Impregnation of the Isopod, *Jaera marina*. By RICHARD ELMHIRST, Esq., F.L.S.
2. Notes on the Reproductive Organs of the Pine Weevil, *Hyllobius abietis*; and
3. Exhibition of Bark-beetles, *Hyalastinus obscurus* and *Phloeophthorus rhododactylus*. By JAMES W. MUNRO, Esq., B.Sc. (Communicated by R. STEWART MACDOUGALL, Esq., M.A., D.Sc., F.R.S.E.)
4. Exhibition of specimens and preparations of the San José Scale-Insect, *Aspidiotus perniciosus*. By R. STEWART MACDOUGALL, Esq., M.A., D.Sc., F.R.S.E.
5. Exhibition of Shed Antlers of Reindeer bearing velvet, from the Scottish Zoological Park. By T. H. GILLESPIE, Esq.

Mr ELMHIRST also exhibited a mounted specimen of *Desmoscolex*.

Monday, 24th January 1914.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

James A. Todd, Esq., M.A., B.Sc., was elected an Ordinary Fellow.

The following Communications were submitted :

1. Natural Arrest of Hæmorrhage from a wound. Illustrated by lantern slides and microscope demonstration. By JOHN TAIT, Esq., M.D., D.Sc. (Introduced by the PRESIDENT.)
 2. An Account of Bird-lice of the genus *Docophorus*, found infesting British Auks. By Rev. JAMES WATERSTON, B.D., B.Sc.
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Monday, 23rd February 1914. —Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

A Resolution "That this Society record its support of the Importation of Plumage (Prohibition) Bill, at present before the Houses of Parliament" was unanimously adopted.

The following Communications were submitted :

1. Exhibition of some cases of Persistent Right Ovary, or "Double Ovary," in Birds. By H. M. VICKERS, Esq.
2. The Occurrence and Distribution of the Lamellicorn Beetle, *Passalus unicornis*, in the Antilles and northern portion of South America. By SYMINGTON GRIEVE, Esq.
3. The Australian "Swallow-tail" Butterflies (Papilionidæ)—their distribution in and beyond Australia; with exhibition of examples illustrating the significance of Local Races; and
4. Exhibition of Male and Female examples of the recently discovered and rare *Ornithoptera alexandrae*—the largest known Butterfly. By PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.
5. Exhibition of Unique Copy of Pennant's "British Zoology," presented by the author to Gilbert White of Selborne, with dedication and marginal notes in the handwriting of the latter. By OLIVER H. WILD, Esq.

Monday, 23rd March 1914.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following Communications were submitted :

1. Exhibition of preparations to illustrate the stages of the Life-history of a Euphausiid Crustacean, probably *Nyctiphanes norvegica*. By RICHARD ELMHIRST, Esq., F.L.S.
2. "Beetle" Mites (Oribatidæ), and other Mites from the Forth Area; and
3. Exhibition of Insects collected on the Isle of May. II. Trichoptera, Coleoptera, etc. By WM. EVANS, Esq., F.F.A., F.R.S.E.
4. Demonstration of preparation of a Sea Urchin (*Echinus esculentus*) to show the arrangement of the internal organs in nature. By J. H. ASHWORTH, Esq., D.Sc.
5. Note on the Limitations of Evolution. By the SECRETARY.

SESSION CXLIV.

Monday, 26th October 1914.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following Communications were submitted :

1. Exhibition of abnormal Limb bones of Shetland Pony. By the PRESIDENT.
2. An Account of Bird-lice of the genus *Docophorus* (Mallophaga) found on British Auks—Morphological. By Rev. JAMES WATERSTON, B.D., B.Sc.
3. Exhibition of a fetal Hybrid Monkey. By T. H. GILLESPIE, Esq.
4. An Account of Spiders collected in Scotland during 1914. By A. RANDELL JACKSON, Esq., M.D., D.Sc. (Communicated by WM. EVANS, Esq., F.F.A., F.R.S.E.)
5. Exhibition of abnormal specimens of Sea Urchins, with some remarks on Growth and Regulation. (Illustrated by lantern slides.) By the SECRETARY.

Monday, 23rd November 1914.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following gentlemen were elected Honorary Fellows in recognition of their long and meritorious services to Zoological Science:—Canon A. Merle Norman, M.A., D.C.L., F.R.S., and Thomas Scott, Esq., LL.D., F.L.S.

Professor Donald Capell Matheson, F.R.C.V.S., D.V.S.M. (Vic.), was elected an Ordinary Fellow.

The Secretary submitted the following Report of Council for the Session :—

The Council begs to submit the following account of the work accomplished during Session 1913-1914. At the statutory six Ordinary meetings of the Society twenty-four communications in all were read, covering a wide field in Zoological and Palaeontological science. The majority of these were illustrated by demonstration of the objects referred to with microscopes or otherwise, or by lantern slides. Seven of the papers have been printed in full, in Parts 5 and 6 of Vol. xix. of the *Proceedings* of the Society, and a few have been held over for future publication when the authors have had opportunity to complete their observations.

A general classification of the published papers will give some notion of the nature of the fresh contributions to scientific knowledge made by the Society during the year. Both vertebrate and invertebrate subjects were represented. Observations of biological interest hold first place in importance, additions of considerable value having been made to our knowledge of the habits and life-histories of the mites of the sea-shore, of bird-parasites (Mallophaga), of the Pine Weevil (*Hylobius*), of the beetle *Passalus unicornis*, and of the cuckoo. Associated with the majority of these observations were detailed accounts of the structures of the creatures discussed, especially of such features as are employed in classification. Four papers deal specifically with systematics and geographical distribution. These record one genus of fossil Myriapods (the first example of a rolling Myriapod from the Carboniferous period) and two species of spiders new to science; eight species of spiders new to the fauna of Britain; and thirteen species of spiders and one sea-shore mite new to the fauna of Scotland. Three papers gave suggestions as to the technique of collecting and preserving special groups of animals; and at least one paper, that on the Development of the Reproductive Organs of the Pine Weevil (*Hylobius abietis*), promises to be of some economic importance in the efforts to eradicate "one of the worst insect enemies of the forester in this country." These scientific papers have been illustrated by three lithographic plates and over twenty figures in the text.

At a recent meeting the Council decided to form a collection of framed portraits of past Presidents of the Society, to hang in the Society's rooms in the Synod Hall. During the past year the first portrait of the series, that of Dr Robert Brown, President from 1870-73, was gifted to the Society.

The year showed no marked fluctuation in the Roll of Fellowship. Four new Fellows have been elected, and one has resigned. But the Society has also lost, by death, two Fellows—Mr Alex. Mackay, of Thurso, and Sir John Murray, K.C.B., Ph.D., LL.D., F.R.S. A motion expressing the regret of the Society at the loss of this distinguished naturalist has already been recorded in the minutes of the Society, at the instance of a General Meeting. The Council exceedingly regrets the reported loss of Mr James Murray of Edgeware, Middlesex, in the Arctic Regions. Mr Murray, who became a Fellow in 1905, was one of the most active of our members in scientific work, first as biologist on the Lake Survey of Scotland, then as biologist on Sir Ernest Shackleton's first Antarctic Expedition. Thereafter he made scientific explorations in the northern parts of South America, and he is reported missing, still in the midst of scientific labours,

on the Stefansson Expedition to the Arctic Regions. He has contributed many valuable papers, mainly on microscopic fresh-water life, to our *Proceedings* and other scientific journals.

At the end of the Session just closed there stood on the Roll of Fellowship, 160 Ordinary, 3 Corresponding, and 5 Honorary Fellows.

In addition to the ordinary series of exchanges, representing the *Proceedings* and *Transactions* of a large number of British, Colonial, and Foreign Scientific Societies, the following books have been specially presented to the library of the Society:—

<i>Title of Book.</i>	<i>Presented by</i>
1. Scientific Results of the Voyage of the "Scotia" . . .	Dr W. S. Bruce.
2. Catalogue of the Hocken Library, Dunedin . . .	The Trustees.
3. Catalogue of the Marine Reptiles of the Oxford Clay (Andrews)	The Trustees of the British Museum (Nat. Hist.).
4. Catalogue of the British Species of Pisidium (Woodward) . . .	Do.
5. Guide to the Exhibition of Specimens illustrating the Structures of Animals in Relation to Flight	Do.
6. Catalogue of the Cretaceous Flora (Stopes)	Do.
7. Geological Survey of Scotland	The Director.
Sheet Memoirs (4 vols.)	
Annual Summary	
8. Langley's "Memoir on Mechanical Flight"	Smithsonian Institution.
9. Reports of the United States Naval Observatory	The Director.
10. Reports of the United States Geological Survey	Do.
11. Le Sporophyte et le Gamétophyte du Végétal	C. Janet, Paris.
12. Constitution morphologique de la Bouche de l'Insecte	Do.
13. Tøren Hjorth—Inventor of the Dynamo-Electric Principle	Carlsberg Foundation.
14. Descrizione di una Macchinetta Electro magnetica del Dr A. Picinotti	The Author.

The following authors have presented pamphlets written by them:—

J. T. Wainwright, Chicago.	A. Landsborough Thomson, M.A., Aberdeen.
C. Janet, Paris.	W. J. Millar, C.E., Rothesay.

The Annual Reports of the Treasurer and Librarian were also submitted.

The following Office-Bearers for the Session 1914-15 were elected:

President—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E.

Vice-Presidents—WM. EVANS, Esq., F.F.A., F.R.S.E.; Professor ARTHUR ROBINSON, M.D.; PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.

Secretary—JAMES RITCHIE, Esq., M.A., D.Sc.

Assistant-Secretary—JAMES A. S. WATSON, Esq., B.Sc., F.R.S.E.

Treasurer—WM. WILLIAMSON, Esq., F.R.S.E.

Librarian—J. H. ASHWORTH, Esq., D.Sc., F.R.S.E.

Councillors—LIONEL W. HINXMAN, Esq., B.A., F.R.S.E.; THEODORE RETTIE, Esq., D.Sc.; SYMINGTON GRIEVE, Esq.; Professor J. COSSAR EWART, M.D., F.R.S.; HUGH MILLER, Esq., F.Z.S.; MALCOLM LAURIE, Esq., B.A., D.Sc.; W. F. P. M'LINTOCK, Esq., B.Sc.; J. KIRKE NASH, Esq., L.D.S.Ed.; B. N. PEACH, Esq., LL.D., F.R.S.L. & E., F.G.S.; J. F. GEMMILL, Esq., M.A., M.D., D.Sc.; JOHN RENNIE, Esq., D.Sc., F.R.S.E.; D. C. M'INTOSH, Esq., M.A., D.Sc., F.R.S.E.

The retiring Vice-President, B. N. PEACH, Esq., LL.D., F.R.S., F.G.S., delivered an address upon "SOME POINTS IN THE NATURAL HISTORY OF THE CARBONIFEROUS PERIOD IN EAST SCOTLAND."

Monday, 21st December 1914.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following Communications were submitted :

1. On a New Starfish larva (Brachiolaria stage), and on the Late Larva of *Luidia ciliaris*. By JAS. F. GEMMILL, Esq., M.A., M.D., D.Sc. (Illustrated by lantern slides.)
 2. An Account of certain Blood Corpuscles of Invertebrates. By JOHN TAIT, Esq., M.D., D.Sc. (Illustrated by lantern slides.)
 3. SPOLIA AUSTRALIENSIA.—Some examples of the Land Fauna. By J. H. ASHWORTH, Esq., D.Sc.
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Monday, 25th January 1915.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

A. Randell Jackson, Esq., M.D., D.Sc., was elected an Ordinary Fellow.

The following Communications were submitted :—

1. Remarks on the various Wasps and Humble-bees found in Scotland, illustrated by specimens. By WM. EVANS, Esq., F.F.A., F.R.S.E.
 2. Exhibition of Nests of British Social Wasps. By OLIVER H. WILD, Esq.
 3. Note on larvæ of the Warble-flies—*Hypoderma bovis* and *H. lineata*—from hides in Scotland, illustrated by specimens of ox skin with larvæ, and tanned hide showing damage. By H. M. STEVEN, Esq. (Communicated by R. STEWART MACDOUGALL, Esq., M.A., D.Sc.)
 4. Exhibition of (a) Warbles of *Hypoderma diana* in Deer with larvæ *in situ*, damaged Red-deer hide, and puparia and adult of Fly; (b) Larvæ of Warble-fly (*Oedemagena torandi*) of Reindeer, and of Warble-flies (*Strobilobius* n. sp. and *Dermatoestrus* n. sp.) from the Antelope, *Cobus letchwe*. By R. STEWART MACDOUGALL, Esq., M.A., D.Sc., F.R.S.E.
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Monday, 22nd February 1915.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., President, in the Chair.

The following Communications were submitted :—

1. Lantern Demonstration of Photographs of Birds in flight. By THE PRESIDENT.
2. *Agarella gracilis*, a new Myxosporidian genus and species from the Lung-fish, *Lepidosiren paradoxa*. By J. S. DUNKERLY, Esq., B.Sc. (Communicated by Professor J. GRAHAM KERR, M.A., F.R.S.)
3. The Cyst of *Amoeba proteus*. By Miss LUCY AGNES CARTER, B.Sc. (Communicated by Professor J. GRAHAM KERR.)
4. Notes on the Habits of the Rhea. By ANDREW PRIDE, Esq. (Communicated by Professor J. GRAHAM KERR.)
5. SPOLIA AUSTRALIENSIA. (ii.) Examples of the Marine Fauna. By J. H. ASHWORTH, Esq., D.Sc.

Monday, 22nd March 1915.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc.,
F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows:—A. Perrin Dixon, Esq., F.Z.S., and John Maclean Ramsay, Esq.

The following Communications were submitted:—

1. Microscope Demonstration of the Trophoblast in a three-weeks' old Horse. By Professor J. COSSAR EWART, M.D., F.R.S.
2. The Larvæ of Wood-boring Beetles—Families Anobiidæ and Lyctidæ. (Illustrated by lantern slides.) By JAMES W. MUNRO, Esq., B.Sc. (Communicated By R. STEWART MACDOUGALL, M.A., D.Sc.)
3. Zoological Notes. By W. D. HENDERSON, M.A., Ph.D., B.Sc., University of Bristol. (Communicated in the Author's absence by the PRESIDENT and SECRETARY.)
 - (a) Note on an Ambicoloured Flounder.
 - (b) The Influence of Nutrition on the Determination of Sex. Remarks on Yunge's Experiments on Tadpoles.
 - (c) Critical remarks on the Alcyonarian, *Paraspongodes striata*.
 - (d) An abnormal Post-caval Vein in the Rabbit.
 - (e) Hermaphrodite Reproductive Organs in the Guinea-Pig.

LIST OF SOCIETIES WHICH RECEIVE THE SOCIETY'S "PROCEEDINGS," AND GUIDE TO SOCIETIES SENDING SERIAL PUBLICATIONS TO THE LIBRARY.

*Those Institutions from which Publications are received in return are
indicated by an asterisk.*

ENGLAND.

BIRMINGHAM, . . .	*Birmingham and Midlands Institute Scientific Society.
Do.	{ *Philosophical and Natural History Society, Avebury House, 55 Newhall Street.
CAMBRIDGE, . . .	*Philosophical Society.
Do.	University Library.
CIRENCESTER, . .	*Editor of the <i>Agricultural Students' Gazette</i> .
NEWCASTLE-ON- TYNE,	{ Armstrong College.
LEEDS,	{ *Yorkshire Geological and Polytechnic Society, The University.
LIVERPOOL, . . .	*Biological Society, University College.
LONDON,	British Museum Library.
Do.	*British (Natural History) Museum, South Kensington
Do.	*Royal Society, Burlington House, Piccadilly, W.
Do.	*Linnean Society, Burlington House, Piccadilly, W.
Do.	*Royal Microscopical Society, King's College.
Do.	Editor of <i>Nature</i> , 29 Bedford Street, Covent Garden.
Do.	Zoological Society, Hanover Square.
MANCHESTER, . .	{ *The Conchological Society of Great Britain and Ireland, The Museum.
Do.	*Literary and Philosophical Society, 36 George Street.
Do.	The Victoria University.
NORWICH,	*Norfolk and Norwich Naturalists' Society, The Museum.
OXFORD,	The Bodleian Library.
TRURO,	*Royal Institution of Cornwall.
WATFORD,	*Hertfordshire Natural History Society and Field Club.

SCOTLAND.

ABERDEEN,	University Library.
COCKBURNSPATH, .	*Berwickshire Naturalists' Field Club, Old Cambus.
EDINBURGH, . . .	Advocates' Library.
Do.	University Library.
Do.	*Royal Society.
Do.	*Royal Scottish Geographical Society.
Do.	*Highland and Agricultural Society.
Do.	*Geological Society.
Do.	*Geological Survey.

GLASGOW.	. . .	*Philosophical Society.
Do.	. . .	*Natural History Society.
Do.	. . .	*Geological Society.
Do.	. . .	University Library.
PERTH.	. . .	*Perthshire Society of Natural History.
ST ANDREWS.	. . .	University Library.

IRELAND.

BELFAST.	. . .	*Natural History and Philosophical Society.
DUBLIN.	. . .	*Royal Irish Academy.
Do.	. . .	*Royal Dublin Society.

HOLLAND.

AMSTERDAM.	. . .	*De Koninklijke Akademie van Wetenschappen.
LEYDEN.	. . .	*Museum van Natuurlijke Histoire.
UTRECHT.	. . .	Provinciaal Genootschap an Kunsten en Wetenschappen.

SWITZERLAND.

BASLE.	. . .	*Die Naturforschende Gesellschaft.
BERN.	. . .	{ *Bibliothek der Schweizerischen Naturforschende Gesellschaft.
GENEVA.	. . .	
NEUCHÂTEL.	. . .	*Société des Sciences Naturelles.
ZÜRICH.	. . .	*Die Naturforschende Gesellschaft.
Do.	. . .	Concilium Bibliographicum.

GERMANY.

BERLIN.	. . .	*Königliche Akademie der Wissenschaften.
Do.	. . .	*Gesellschaft Naturforschender Freunde.
BONN.	. . .	{ *Naturhistorischer Verein der preussischen Rheinlande Westfalens, und des Reg.-Bezirks Osnabrück.
BREMEN.	. . .	
BRESLAU.	. . .	*Schlesische Gesellschaft für Vaterländische Cultur.
BRUNSWICK.	. . .	*Naturwissenschaftlicher Verein.
DRESDEN.	. . .	Königliche Sammlungen für Kunst und Wissenschaft.
Do.	. . .	The Museum.
ELBERFELD.	. . .	*Naturwissenschaftlicher Verein.
ERLANGEN.	. . .	University Library.
Do.	. . .	*Physikalisch Medizinischen Sozietät.
FRANKFORT-ON-MAIN.	. . .	*Senckenbergische Naturforschende Gesellschaft.
Do.	. . .	{ *Deutsche Malakozoologische Gesellschaft, Dr Kobelt. Schwanheim.
FREIBURG, i. B.	. . .	
GÜTTINGEN.	. . .	*Königliche Gesellschaft der Wissenschaften.
HALLE.	. . .	*Kaiserliche Akademie der Naturforscher.
HAMBURG.	. . .	Naturhistorisches Museum.
JENA.	. . .	*Medicinish-naturwissenschaftliche Gesellschaft.
LEIPZIG.	. . .	*Königliche Sächsische Gesellschaft der Wissenschaften.
MUNICH.	. . .	*Königliche Baierische Akademie der Wissenschaften.
STUTTGART.	. . .	*Verein für Vaterländische Cultur in Württemberg.
WÜRZBURG.	. . .	*Physikalisch-medicinische Gesellschaft.

AUSTRIA.

AGRAM, . . .	*Societas Croatica Historico-naturalis.
HERMANNSTADT, . .	*Siebenbürgischer Verein für Naturwissenschaft.
PRAGUE, . . .	*Königliche-böhmische Gesellschaft der Wissenschaften.
TRIESTE, . . .	Società Adriatica di Scienze Naturali.
VIENNA, . . .	*K.k. zoologisch-botanische Gesellschaft.
Do. . . .	*K.k. Naturhistorisches Hof-Museum.

ITALY.

BOLOGNA, . . .	*Accademia delle Scienze dell' Istituto.
MILAN, . . .	*Reale Istituto Lombardo di Scienze, Lettere ed Arti.
Do. . . .	*Società Italiana di Scienze Naturali.
MODENA, . . .	*Società dei Naturalisti.
NAPLES, . . .	Editor of the <i>Zoologischer Jahresbericht</i> , Zoological Station.
PADUA, . . .	*Società Veneto-Trentina di Scienze Naturali residente in Padova.
ROME, . . .	
TURIN, . . .	*Reale Accademia dei Lincei.
	*Reale Accademia delle Scienze.

SPAIN.

MADRID, . . .	*Real Academia de Ciencias exactas, físicas e naturales.
Do. . . .	{ *Real Sociedad Española de Historia Natural (Museo de Ciencias Naturales), Hipódromo.

PORTUGAL.

COIMBRA, . . .	*Bibliothèque de l'Université.
LISBON, . . .	Academia Real das Sciencias.
OPORTO, . . .	*Academia Polytechnica.

FRANCE.

BORDEAUX, . . .	La Société Linnéenne.
CAEN, . . .	*Société Linnéenne de Normandie.
CHERBOURG, . . .	*Société Nationale des Sciences Naturelles.
PARIS, . . .	*Académie des Sciences de l'Institut.
Do. . . .	*Société Géologique de France, Rue des grands Augustins, 7.
Do. . . .	*Société Zoologique de France, Rue des grands Augustins, 7.
Do. . . .	Société de Biologie.

BELGIUM.

BRUSSELS, . . .	{ *Académie Royale des Sciences, des Lettres, et des beaux Arts.
Do. . . .	*Société Royale Malacologique de Belgique.
Do. . . .	*Société Royale Botanique de Belgique.

NORWAY.

BERGEN, . . .	*The Museum.
CHRISTIANIA, . . .	{ *Professor Dr N. Wille, "Nyt Magazin for Naturvidensk- aberne," Christiania, Norway.
Do. . . .	Universitets Bibliothek.

DENMARK.

COPENHAGEN,	.	.	*Danish Biological Station.
Do.	.	.	*Kongelige Danske Videnskabernes Selskab.
Do.	.	.	*Naturhistoriske Forening.

SWEDEN.

STOCKHOLM,	.	.	*Kongliga Svenska Vetenskaps-Akademie.
UPSALA,	.	.	*Kongliga Vetenskaps-Societeten.
Do.	.	.	*Observatoire Météorologique.

RUSSIA.

DORPAT,	.	.	*Naturforscher Gesellschaft.
KIEV,	.	.	*Natural History Society.
MOSCOW,	.	.	*Société Impériale des Naturalistes.
ST PETERSBURG,	.	.	*Académie Impériale des Sciences.
Do.	.	.	*Imperial Botanic Garden.
WARSAW,	.	.	*Société Scientifique.

AMERICA.

UNITED STATES.

ALBANY, N. Y.,	.	.	*New York State Library.
BALTIMORE,	.	.	*Johns-Hopkins University Library.
BOSTON,	.	.	*American Academy of Arts and Sciences.
Do.	.	.	*Society of Natural History.
CALIFORNIA,	.	.	*University of California.
CAMBRIDGE, MASS.,	.	.	Harvard University Library.
Do.	.	.	*Museum of Comparative Zoology.
CHICAGO,	.	.	*Academy of Sciences.
CINCINNATI,	.	.	*Society of Natural History.
INDIANAPOLIS,	.	.	*Academy of Science.
NEWHAVEN, CONN.,	.	.	*Connecticut Academy of Arts and Sciences.
NEW YORK,	.	.	*New York Academy of Sciences.
PHILADELPHIA,	.	.	*Academy of Natural Sciences.
ROCHESTER, N. Y.	.	.	*Academy of Science.
SAN FRANCISCO,	.	.	*California Academy of Sciences.
ST LOUIS,	.	.	*Academy of Sciences.
WASHINGTON,	.	.	*Smithsonian Institute.
Do.	.	.	*United States National Museum.
Do.	.	.	*United States Geological Survey.
Do.	.	.	United States Commissioner of Fish and Fisheries.
WISCONSIN,	.	.	*Academy of Sciences, Arts, and Letters.

MEXICO.

MEXICO,	.	.	{ *Ministerio de Fomento de la Republica, Osservatori Meteorologico.
Do.	.	.	*Sociedad Científica, "Antonio Alzate," Mexico.

CANADA.

KINGSTON,	.	.	*Queen's University.
MANITOBA,	.	.	*Historical and Scientific Society, Winnipeg.
MONTREAL,	.	.	*The Natural History Society.
OTTAWA,	.	.	*Canadian Geological Survey.
Do.	.	.	*Royal Society of Canada.
TORONTO,	.	.	*The Canadian Institute.

List of Societies, etc.

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NOVA SCOTIA.

HALIFAX, . . . *Nova Scotia Institute of Natural Science.

PERU.

LIMA, . . . *Cuerpo de Ingerieros de Minas.

BRAZIL.

RIO DE JANEIRO, . . *Museu Nacional.

Do. . . *Instituto Oswaldo Cruz.

AFRICA.

CAPE TOWN, . . . *The Royal Society of South Africa.

EGYPT.

CAIRO, . . . Université Egyptienne, Bibliothèque.

ASIA.

BATAVIA. . . { *Koninklijke Natuurskundige Vereeniging in Nederlandsch
Indie.

CALCUTTA, . . . Royal Asiatic Society of Bengal.

COLOMBO, . . . *Colombo Museum, Ceylon.

TOKIO, JAPAN, . . *Imperial University of Japan.

AUSTRALASIA.

ADELAIDE, . . . *Royal Society of South Australia.

BRISBANE . . . *The Queensland Museum.

HOBART . . . *Royal Society of Tasmania.

MELBOURNE, . . . *Royal Society of Victoria.

SYDNEY, . . . *Royal Society of New South Wales.

Do. . . . *The Australian Museum.

Do. . . . *Linnean Society of New South Wales.

WELLINGTON, . . . *New Zealand Institute.

LIST OF FELLOWS

At 1st October 1915.

*Those marked * are Life Members.*

Date of
Election.

1905. Agar, W. E., B.A., D.Sc., 1 Eton Gardens, Hillhead, Glasgow.
1905. Anderson, T. J., B.Sc., Nairobi, British East Africa.
1901. Annandale, Nelson, B.A., D.Sc., The Museum, Calcutta.
1902. *Ashworth, J. H., D.Sc., Zoological Laboratory, University.
1907. *Bagnall, R. S., Oldstead, Park Town, Oxford.
1904. Bailey, Edward B., B.A., H.M. Geological Survey, 33 George Square.
1885. Barbour, A. H. F., M.A., B.Sc., M.D., 4 Charlotte Square.
1904. Beare, Professor T. Hudson, B.A., B.Sc., M.Inst.C.E., University.
1880. *Beddard, Frank E., M.A., F.R.S., Zoological Gardens, London.
1881. *Berry, W., Tayfield, Newport, Fife.
1902. Black, J. Wyclif, F.C.S., 67 Falcon Road.
1912. Blackwood, G. G., F.F.A., 2 Bellevue Crescent.
1906. *Bowhill, Jas. Wm, B.A., Morelands, Grange Loan.
1892. Bowhill, Thomas, F.R.C.V.S., 1445 6th Avenue, Fairview, Vancouver, British Columbia.
1893. *Bradley, O. Charnock, M.D., D.Sc., F.R.S.E., Royal Veterinary College.
1913. Brock, Sydney E., Overton, Kirkliston.
1876. Brown, J. A. Harvie, LL.D., F.Z.S., F.R.S.E., Dunipace House, Larbert.
1891. Brown, Richard, C.A., 23 St Andrew Square.
1904. Brown, R. N. Rudmose, D.Sc., The University, Sheffield.
1907. Brown, Wm., M.R.C.V.S., Catterloch, Banchor, by Aberdeen.
1876. *Bruce, W. P., Kinleith Mill, Currie.
1894. Bruce, W. S., LL.D., F.R.S.E., F.R.S.G.S., Scottish Oceanographical Laboratory, Surgeons' Hall.
1907. Bryce, T. H., Professor, M.A., M.D., No. 2, The University, Glasgow.
1910. Caird, Wm. J., School-house, Sandhaven, Fraserburgh.
1893. Campbell, Kenneth Findlater, C.E., Hon.M.Inst.C.E., M.S.I., Borough Engineers' Office, Huddersfield.
1876. *Carmichael, His Excellency Lord, of Skirling, Governor-General, Madras, India.
1858. Carruthers, W., F.R.S., 44 Central Hill, Norwood, London, S.E.
1888. Clarke, Wm. Eagle, F.L.S., F.R.S.E., Royal Scottish Museum.
1895. *Clough, C. T., M.A., H.M. Geological Survey, 33 George Square.
1881. Cook, C., W.S., 11 Belgrave Crescent.
1902. Cowan, Francis, C.A., Westerlea, Murrayfield.
1900. *Crampton, Cecil B., M.B., C.M., H.M. Geological Survey, 33 George Square.
1874. Crawford, W. C., M.A., 1 Lockharton Gardens, Colinton Road.
1877. *Dalglish, J. J., Brankston Grange, Bogside Station, Alloa.
1894. Day, T. Cuthbert, F.C.S., 36 Hillside Crescent.

Date of
Election.

1913. Dinham, C. H., 33 George Square, Edinburgh.
1915. Dixon, A. Perrin, F.Z.S., Zoological Park, Murrayfield.
1895. Douglas, William, 9 Castle Street.
1909. Drennan, A. M., M.B., Ch.B., Pathology Department, University.
1910. Elmhirst, R., F.L.S., Superintendent, Marine Biological Station, Millport.
1889. Elsworth, R. C., M.D., F.R.C.S. (Eng.), St Helen's Road, Swansea.
1880. *Evans, Wm., F.F.A., F.R.S.E., 38 Morningside Park.
1883. Ewart, Professor J. Cossar, M.D., F.R.S., University.
1902. Farquharson, David A., M.B., C.M., Royal Veterinary College.
1884. *Ferguson, James A. E., M.B., Eccles, East Bank, Demerara, British Guiana.
1885. Ferguson, James Haig, M.D., F.R.C.P.E., 7 Coates Crescent.
1906. Geddes, A. Campbell, M.D., Department of Anatomy, M'Gill University, Montreal, Canada.
1911. Gemmill, J. F., M.A., M.D., D.Sc., 12 Ann Street, Hillhead, Glasgow.
1913. Gillespie, T. H., Director-Secretary, Zoological Park, Corstorphine.
1906. Gofton, A., F.R.C.V.S., Royal Veterinary College.
1909. Gordon, Mrs Ogilvie, D.Sc., Ph.D., F.L.S., 1 Rubislaw Terrace, Aberdeen.
1909. Gray, Mrs Elizabeth, 59 George Street.
1877. Grieve, Somerville, 21 Queen's Crescent.
1886. Grieve, Symington, 11 Lauder Road.
1893. Grimshaw, Percy H., F.E.S., F.R.S.E., Royal Scottish Museum.
1913. Gumpert, Eugene, 15 Heathfield North, Twickenham, Middlesex.
1893. *Guppy, H. B., M.B., F.R.S.E., E.M.A., Rosario, Salcombe, S. Devon.
1899. Hay, Wm. Peach, M.B., C.M., Lincoln Road, Peterborough.
1905. Henderson, D. W., M.A.
1883. Henderson, J. R., M.B., C.M., F.L.S., Government Museum, Madras, India.
1913. Henderson, W. D., M.A., B.Sc., Ph.D., F.R.S.E., The University, Bristol.
1883. Hepburn, Professor David, V.D., M.D., C.M., M.R.C.S. (Eng.), F.R.S.E., University College, Cardiff.
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1904. *Ingram, B., F.R.C.S.E., Balfour, Tasmania.
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1903. Jamieson, E. B., M.D., Anatomy Department, University.
1895. *Johnston, Colonel Henry Halcro, D.Sc., M.D., F.L.S., late Medical Army Service, Orphir House, Orphir, Kirkwall, Orkney.

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- Date of Election.
1907. Johnston, T. B., M.B., Ch.B., 33 Grange Road.
1898. Johnston, T. Nicol, M.B., C.M., F.R.S.E., Pogbie, Upper Keith, E. Lothian.
1906. Jolly, W. A., M.B., Ch.B., South African College, Cape Town.
1869. *Kennedy, Rev. J., M.A., B.D., 9 Hartington Place.
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1903. Leighton, Gerald R., M.D., F.R.S.E., Local Government Board, Edinburgh.
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 1909. Robertson, Miss Muriel, Lister Institute of Preventative Medicine,
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 1909. Robinson, Professor Arthur, M.D., University—*President*.
 1894. Roebuck, W. Denison, F.L.S., 259 Hyde Park Road, Leeds.
 1900. Schäfer, Professor Sir E. A., LL.D., F.R.S., University.
 1909. Simpson, James J., M.A., B.Sc., Academy Street, Elgin.
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 1886. *Somerville, Professor Wm., M.A., B.Sc., F.L.S., F.R.S.E.,
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 1876. *Thomson, John.
 1906. Thomson, R. B., M.B., Ch.B., Anatomy Department, South African
 College, Cape Town.
 1914. Todd, James A., M.A., B.Sc., 86 Montpelier Park, Edinburgh.
 1885. Tomlinson, Henry T., M.B., C.M., Coton Road, Nuneaton.
 1905. Troup, R. D. R., The Grove, Wembdon, Bridgewater.
 1858. *Turner, Sir Wm., K.C.B., M.B., D.Sc., D.C.L., LL.D., F.R.S.,
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 1913. Watson, Jas. A. S., B.Sc., F.R.S.E., The University, Edinburgh.
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 ment, Surgeons' Hall.
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 1911. Wild, Oliver H., 29 Viewforth, Edinburgh
 1890. Williams, John Robert, M.B., C.M., J.P., Ardre, Penmaenmawr.
 1909. Williamson, Henry Chas., M.A., D.Sc., Marine Laboratory, Aberdeen.
 1908. Williamson, Wm., F.R.S.E., 79 Morningside Drive.—*Treasurer*.
 1895. *Wilson, Professor Gregg, Ph.D., D.Sc., University, Belfast.
 1883. *Woodhead, Professor G. Sims, M.D., F.R.S.E., University, Cambridge.
 1896. Yeoman, John B., M.B., C.M., Neston, Cheshire.

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 1871. Grieve, A. F. Brisbane, Queensland.
 1885. Nathorst, Professor A. G., Naturhistoriska Riksmuseum, Stockholm.

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1883. Geikie, Sir Archibald (Ord. Fellow 1878), London, *Olim Præses*; Shepherd's Down, Haslemere, Surrey.
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 1893. Lapworth, Professor, F.R.S., 38 Calthorpe Road, Edgbaston, Birmingham.
 1914. Norman, Rev. Canon A. Merle, M.A., D.C.L., F.R.S. (Ord. Fellow 1888), The Red House, Berkhamsted, Herts.
 1914. Scott, Thomas, LL.D. (Ord. Fellow 1889), 2 Devanah Terrace, Aberdeen.
 1888. Vines, Sydney H., M.A., F.R.S., The Botanic Gardens, Oxford.

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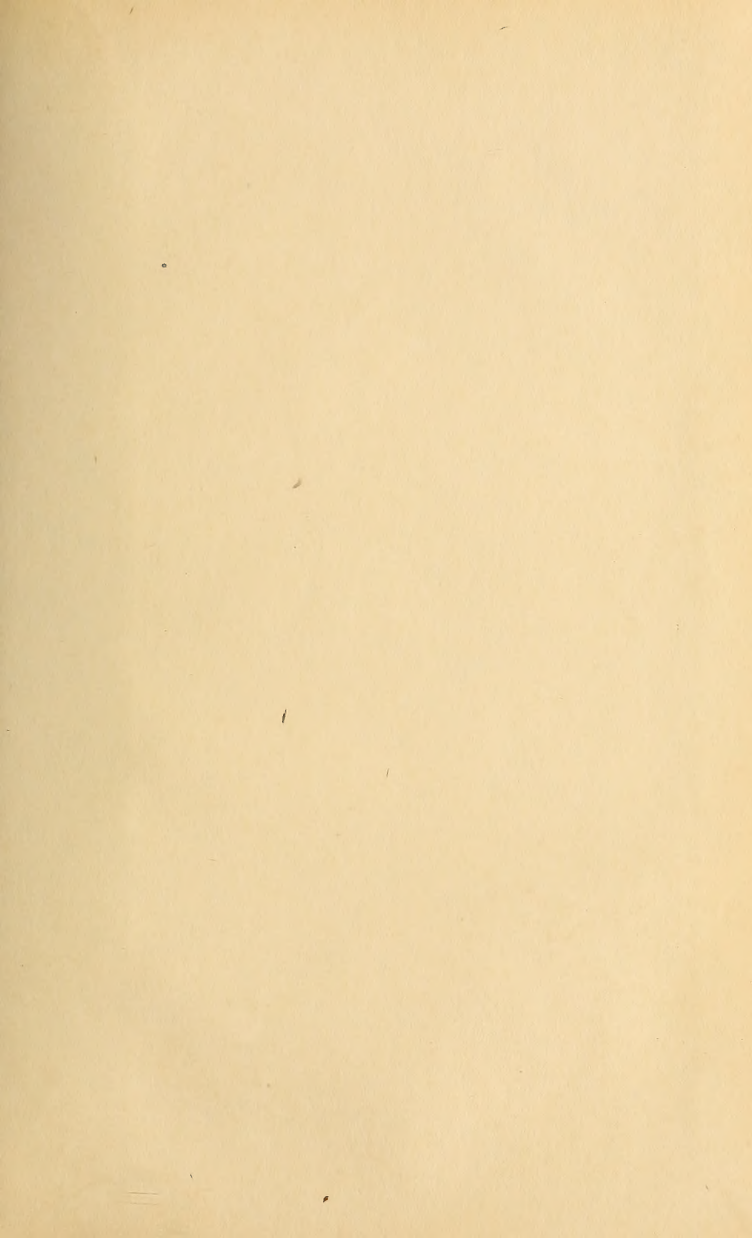
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